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Jean-loup Gailly Mark Adler
j loup@gzip.org madler@alumni.caltech.edu

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**Volume Overview**

This manual describes the structure, operation, and functions of the Intel® Integrated Performance Primitives (Intel® IPP) that operate on two-dimensional signals and are used for image and video processing. The manual explains the Intel IPP concepts, as well as specific data type definitions and operation models used in the image and video processing domain, and provides detailed descriptions of the Intel IPP image and video processing functions. The Intel IPP functions are combined in groups by their functionality. Each group of functions is described in a separate chapter (chapters 3 through 16).

For more information about image and video processing concepts and algorithms, refer to the books and materials listed in the Bibliography.

**What's New**

This Developer Reference documents Intel® Integrated Performance Primitives (Intel® IPP) 2019 Update 4 release.

The document has been updated to reflect the following changes to the product:

**Intel® IPP 2019 Update 4**

Minor updates have been made to fix inaccuracies in the document.

**Intel® IPP 2019 Update 1**

- Added the `ResizeSetMode` function.
- Added new flavors to the `FilterGaussian` and `FilterGaussianGetSpecSize` functions. See Fixed Filters for details.
- Added new flavors to the `FilterSeparable`, `FilterSeparableInit`, `FilterSeparableGetBufferSize`, and `FilterSeparableGetSpecSize` functions. See Separable Filters for details.
- Added new flavors to the `CopyConstBorder` and `CopyReplicateBorder` functions. See 3D Data Processing Functions for details.
- Added new flavors to the `CFAToBGRA`, `MorphSetMode`, and `CopyConstBorder` functions.

Additionally, minor updates have been made to fix inaccuracies in the document.

**Intel® IPP 2019**

- Added new Threading Layer (TL) APIs for several functions. See Threading Layer Functions
- Added Threading Layer support functions
- Added the `FilterMedian`, `FilterMedianInit`, and `FilterMedianGetSize` functions. See 3D Data Processing Functions for details.
- Added new flavors to the `FilterBorder`, `FilterBorderInit`, and `FilterBorderGetSize` functions. See 3D Data Processing Functions for details.
- Added new flavors to the `FilterBilateral`, `FilterBilateralInit`, and `FilterBilateralGetSize` functions. See Filters with Borders for details.
- Added new flavors to the `LabToRGB` and `RGBToLab` functions. See Color Model Conversion for details.

Additionally, minor updates have been made to fix inaccuracies in the document.
Notational Conventions

The code and syntax used in this manual for function and variable declarations are written in the ANSI C style. However, versions of Intel IPP for different processors or operating systems may, of necessity, vary slightly.

Optimization Notice

Intel's compilers may or may not optimize to the same degree for non-Intel microprocessors for optimizations that are not unique to Intel microprocessors. These optimizations include SSE2, SSE3, and SSSE3 instruction sets and other optimizations. Intel does not guarantee the availability, functionality, or effectiveness of any optimization on microprocessors not manufactured by Intel. Microprocessor-dependent optimizations in this product are intended for use with Intel microprocessors. Certain optimizations not specific to Intel microarchitecture are reserved for Intel microprocessors. Please refer to the applicable product User and Reference Guides for more information regarding the specific instruction sets covered by this notice.

Notice revision #20110804

This manual uses the following notational conventions:

<table>
<thead>
<tr>
<th>Convention</th>
<th>Explanation</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>THIS TYPE STYLE</td>
<td>Used in the text for the Intel IPP constant identifiers.</td>
<td>IPPI_INTER_LINEAR</td>
</tr>
<tr>
<td>This type style</td>
<td>Mixed with the uppercase in structure names; also used in function names, code examples and call statements.</td>
<td>IpplSize,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ippiMomentInitAlloc()</td>
</tr>
<tr>
<td>This type style</td>
<td>Parameters in function prototypes and parameters description.</td>
<td>value, srcStep</td>
</tr>
<tr>
<td>x(n) and x[n]</td>
<td>Used to represent a discrete 1D signal. The notation x(n) refers to a conceptual signal, while the notation x[n] refers to an actual vector. Both of these are annotated to indicate a specific finite range of values.</td>
<td>x[n], 0 ≤ n &lt; len</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Typically, the number of elements in vectors is denoted by len. Vector names contain square brackets as distinct from vector elements with current index n. The expression pDst[n] = pSrc[n] + val implies that each element pDst[n] of the vector pDst is computed for each n in the range from 0 to len - 1. Special cases are regarded and described separately.</td>
</tr>
<tr>
<td>Ipp&lt;data-domain&gt; and Ipp prefixes</td>
<td>All structures and enumerators, specific for the image and video processing domain have the Ippi prefix, while those common for entire Intel IPP software have the Ipp prefix.</td>
<td>IppiPoint, IppDitherType</td>
</tr>
</tbody>
</table>

See Also
Function Naming
This chapter explains the purpose and structure of the Intel® Integrated Performance Primitives (Intel® IPP) for Intel® Architecture software and looks over some of the basic concepts used in the image part of Intel IPP. It also describes the supported data formats and operation modes, and defines function naming conventions in the document.

Function Naming

Naming conventions for the Intel IPP functions are similar for all covered domains. Function names in Intel IPP have the following general format:

```
ipp<data-domain><name>_<datatypedescriptor>[_extension](<parameters>);
```

The elements of this format are explained in the sections that follow.

Data-Domain

The data-domain is a single character that denotes the subset of functionality to which a given function belongs. The current version of Intel IPP supports the following data-domains:

- **s** for signals (expected data type is a 1D signal)
- **i** for images and video (expected data type is a 2D image)
- **m** for matrices (expected data type is a matrix)
- **r** for realistic rendering functionality and 3D data processing (expected data type depends on supported rendering techniques)
- **g** for signals of fixed length

For example, function names that begin with ippi signify that respective functions are used for image or video processing.

Name

The name field identifies what function does and has the following format:

```
<name> = <operation>[_modifier]
```

The operation component is one ore more words, acronyms, and abbreviations that describe the core operation.

The modifier component, if present, is a word or abbreviation that denotes a slight modification or variation of the given function.

For example, names without modifiers: Add, RGBToYChCr, MorphAddGetSize; with modifiers: DCT8x8Inv_2x2, DCT8x8Inv_4x4, RGBToYChCr_JPEG.

Data Types

The datatype field indicates data types used by the function, in the following format:
<bit depth><bit interpretation>,

where

\[
\text{bit depth} = \langle 1|8|16|32|64 \rangle
\]

and

\[
\text{bit interpretation} = \langle u|s|f \rangle[c]
\]

Here \(u\) indicates "unsigned integer", \(s\) indicates "signed integer", \(f\) indicates "floating point", and \(c\) indicates "complex".

Intel IPP supports the following data types for image and video processing functions:

- \(8u\) 8 bit, unsigned data
- \(8s\) 8 bit, signed data
- \(16u\) 16 bit, unsigned data
- \(16uc\) 16-bit, complex unsigned short data
- \(16s\) 16 bit, signed data
- \(16sc\) 16-bit, complex short data
- \(32u\) 32 bit, unsigned data
- \(32s\) 32 bit, signed data
- \(32sc\) 32-bit, complex int data
- \(32f\) 32-bit, single-precision real floating point data
- \(32fc\) 32-bit, single-precision complex floating point data
- \(64s\) 64-bit, quadword signed data
- \(64f\) 64-bit, double-precision real floating point data

† - only partial support for intermediate result after transforms (in the so-called “time” domain).

**NOTE**

For image processing functions that do not support \(1u\) data type, convert bitonal images to \(8u\) gray scale images using the `ippiConvert_1u8u_C1R` function.

The formats for complex data are represented in Intel IPP by structures defined as follows:

```c
typedef struct {     Ipp16s re;     Ipp16s im; } Ipp16sc;

typedef struct {     Ipp32s re;     Ipp32s im; } Ipp32sc;

typedef struct {     Ipp32f re;     Ipp32f im; } Ipp32fc;
```

where \(re\), \(im\) denote the real and imaginary parts, respectively.

Complex data formats are used by several arithmetic image processing functions. The \(32fc\) format is also used to store input/output data in some Fourier transform functions.

The 64-bit formats, \(64s\) and \(64f\), are used for storing data computed by some image statistics functions.

For functions that operate on a single data type, the `datatype` field contains only one of the values listed above.

If a function operates on source and destination images that have different data types, the respective data type identifiers are listed in the function name in order of source and destination as follows:

\[
<\text{datatype}> = <\text{src1Datatype}>[\text{src2Datatype}][\text{dstDatatype}]
\]
For example, the function that converts 8-bit unsigned source image data to 32-bit floating point destination image data has the \texttt{8u32f} value for the \textit{datatype} field.

\textbf{NOTE}
In the lists of function parameters (arguments), the Ipp prefix is written in the data type. For example, the 8-bit unsigned data is denoted as \texttt{Ipp8u} type. These Intel IPP-specific data types are defined in the respective library header files.

\section*{Descriptors}
The descriptors field further describes the operation. Descriptors are individual characters that indicate additional details of the operation.

The following descriptors are used in image and video processing functions:

<table>
<thead>
<tr>
<th>Descriptor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Image data contains an alpha channel as the last channel, requires C4, alpha-channel is not processed</td>
</tr>
<tr>
<td>A0</td>
<td>Image data contains an alpha channel as the first channel, requires C4, alpha-channel is not processed</td>
</tr>
<tr>
<td>C1, C2, C3, C4</td>
<td>Image data is in pixel order and made up of 1, 2, 3 or 4 discrete interleaved channels</td>
</tr>
<tr>
<td>C</td>
<td>Channel of interest (COI) is used in the operation</td>
</tr>
<tr>
<td>I</td>
<td>Operation is performed in-place - that is result of operation is written back into the source (default is not-in-place)</td>
</tr>
<tr>
<td>M</td>
<td>Operation uses a mask to determine pixels to be processed</td>
</tr>
<tr>
<td>P2, P3, P4</td>
<td>Image data is in planar order and made up of 2, 3 or 4 discrete planar (non-interleaved) channels, with a separate pointer to each plane</td>
</tr>
<tr>
<td>R</td>
<td>Function operates on a defined region of interest (ROI) for each source image</td>
</tr>
<tr>
<td>Sfs</td>
<td>Saturation and fixed scaling mode is used</td>
</tr>
<tr>
<td>s</td>
<td>Saturation and no scaling (default)</td>
</tr>
<tr>
<td>V</td>
<td>Function operates on a defined volume of interest (VOI) for each source image</td>
</tr>
</tbody>
</table>

If more that one descriptor is used, they are presented in the function name in alphabetical order.

Every function that operates on image data has a channel count descriptor \texttt{Cn} (for interleaved image) or \texttt{Pn} (for planar). No default channel count is defined.

If input and output channel layouts are different, both source and destination layouts are listed. For example, the function \texttt{ippiHLSToBGR\_8u\_C3P3R} converts three-channel interleaved HLS image to the three-plane BGR image.

\section*{Parameters}
The parameters in functions are in the following order: all source operands, all destination operands, all other operation-specific parameters.
Source parameters are named \textit{Src} or \textit{SrcN}, if there is more than one input image. Destination parameters are named \textit{Dst}. For in-place operations, the input/output parameter contains the name \textit{SrcDst}. All parameters defined as pointers start with lowercase \textit{p}, for example, \textit{pSrc}, \textit{pMean}, \textit{pSpec}.

\textbf{Extensions}

The \textit{extension} field denotes an Intel IPP extension to which the function belongs. The following extensions are supported in Intel IPP Image Processing functions:

<table>
<thead>
<tr>
<th>Extension</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Intel IPP platform-aware functions</td>
<td>\textit{ippiAddC_8u_AC4R_L}</td>
</tr>
<tr>
<td>LT</td>
<td>Intel IPP threading layer (TL) functions based on the Platform Aware API</td>
<td>\textit{ippiSubC_8u_C1RSfs_LT}</td>
</tr>
<tr>
<td>T</td>
<td>Intel IPP threading layer (TL) functions based on the Classic API</td>
<td>\textit{ipprFilterMedian_64f_C1V_T}</td>
</tr>
</tbody>
</table>

\textbf{See Also}

\textit{Platform-Aware Functions for Image Processing}
\textit{Threading Layer Functions}

\textbf{Function Prototypes in Intel IPP}

Function names in Intel IPP contain \textit{datatype} and \textit{descriptor} fields after the \textit{name} field (see \textit{Function Naming} section in this chapter). Most of the Intel IPP functions for image processing have a number of flavors that differ in data types associated with the operation, and in some additional parameters.

Each function flavor has its unique prototype used in function definition and for calling the function from the application program. For many flavors of a given function, these prototypes look quite similar.

To avoid listing all the similar prototypes in function description sections of some chapters in this document, only different templates for such prototypes followed by the table of applicable data types and descriptors for each function may be given. For simplicity, in such cases the data type and descriptor fields in the function name are denoted as \textit{mod}:

\[ <\textit{mod}> = <\textit{datatype}>_{<\textit{datatype}>} \]

For example, the template for the prototype of the image dilation function that performs not-in-place operation, looks like this:

\[
\text{IppStatus ippiDilate}_<\textit{mod}>(\text{const Ipp}<\textit{datatype}>\ast pSrc, \text{int srcStep}, \text{Ipp}<\textit{datatype}>\ast pDst, \text{int dstStep}, \text{IppiSize roiSize});
\]

where the supported values for \textit{mod} are:

\begin{itemize}
  \item \textit{8u\_C1R}
  \item \textit{8u\_C3R}
  \item \textit{8u\_AC4R}
\end{itemize}

This notation means that the \textit{ippiDilate} function has three flavors for a not-in-place operation, which process 8-bit unsigned data (of \textit{Ipp8u} type) and differ in the number of channels in processed images. These flavors have the following prototypes:

\[
\begin{align*}
\text{IppStatus ippiDilate\_8u\_C1R}(\text{const Ipp8u}\ast pSrc, \text{int srcStep}, & \text{IppSize roiSize}); & \text{Ipp8u}\ast pDst, \text{int dstStep}, \\
\text{IppStatus ippiDilate\_8u\_C3R}(\text{const Ipp8u}\ast pSrc, \text{int srcStep}, & \text{IppSize roiSize}); & \text{Ipp8u}\ast pDst, \text{int dstStep}, \\
\text{IppStatus ippiDilate\_8u\_AC4R}(\text{const Ipp8u}\ast pSrc, \text{int srcStep}, & \text{IppSize roiSize}); & \text{Ipp8u}\ast pDst, \text{int dstStep},
\end{align*}
\]

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\[
\begin{align*}
\text{IppStatus ippiDilate\_8u\_C1R}(\text{const Ipp8u}\ast pSrc, \text{int srcStep}, & \text{IppSize roiSize}); & \text{Ipp8u}\ast pDst, \text{int dstStep}, \\
\text{IppStatus ippiDilate\_8u\_C3R}(\text{const Ipp8u}\ast pSrc, \text{int srcStep}, & \text{IppSize roiSize}); & \text{Ipp8u}\ast pDst, \text{int dstStep}, \\
\text{IppStatus ippiDilate\_8u\_AC4R}(\text{const Ipp8u}\ast pSrc, \text{int srcStep}, & \text{IppSize roiSize}); & \text{Ipp8u}\ast pDst, \text{int dstStep},
\end{align*}
\]

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Function names in Intel IPP contain \textit{datatype} and \textit{descriptor} fields after the \textit{name} field (see \textit{Function Naming} section in this chapter). Most of the Intel IPP functions for image processing have a number of flavors that differ in data types associated with the operation, and in some additional parameters.

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For example, the template for the prototype of the image dilation function that performs not-in-place operation, looks like this:

\[
\text{IppStatus ippiDilate}_<\textit{mod}>(\text{const Ipp}<\textit{datatype}>\ast pSrc, \text{int srcStep}, \text{Ipp}<\textit{datatype}>\ast pDst, \text{int dstStep}, \text{IppiSize roiSize});
\]

where the supported values for \textit{mod} are:

\begin{itemize}
  \item \textit{8u\_C1R}
  \item \textit{8u\_C3R}
  \item \textit{8u\_AC4R}
\end{itemize}

This notation means that the \textit{ippiDilate} function has three flavors for a not-in-place operation, which process 8-bit unsigned data (of \textit{Ipp8u} type) and differ in the number of channels in processed images. These flavors have the following prototypes:

\[
\begin{align*}
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\text{IppStatus ippiDilate\_8u\_C3R}(\text{const Ipp8u}\ast pSrc, \text{int srcStep}, & \text{IppSize roiSize}); & \text{Ipp8u}\ast pDst, \text{int dstStep}, \\
\text{IppStatus ippiDilate\_8u\_AC4R}(\text{const Ipp8u}\ast pSrc, \text{int srcStep}, & \text{IppSize roiSize}); & \text{Ipp8u}\ast pDst, \text{int dstStep},
\end{align*}
\]
Thus, to obtain the full name and parameters list for the specific function flavor, not listed directly, do the following:

1. Choose the function operation mode (denoted in this document as **Case 1, 2** and so on) and look in the table for the supported data types and descriptors.
2. Set the `mod` field in the function name as the concatenation of the chosen data type and descriptor, delimited by the underscore.
3. Use the respective template, substituting all the `datatype` fields in the parameters list with the chosen data type. Note that `Ipp` prefix is written before the `datatype` in the parameters list (see **Data Types** in this chapter for details).

**Example**

To get the prototype for the `ippiSet` function flavor that sets each channel of a 3-channel destination image to 16-bit signed values, choose **Case 2: Setting each color channel to a specified value** and use `datatype = 16s, descriptors = C3R`.

After substituting the `mod` field with `16s_C3R`, obtain the required prototype as

```c
ippiSet_16s_C3R(const Ipp16s value[3], Ipp16* pDst, int dstStep, IppiSize roiSize);
```

### Rounding Mode

As many Intel IPP functions have to meet the bit-exact requirement, image processing functions use rounding. The default rounding mode for all functions can be described as "nearest even", that is the fixed point number $x = N + \alpha$, $0 \leq \alpha < 0$, where $N$ is an integer number, is rounded as given by:

\[
\lceil x \rceil = \begin{cases} 
N, & 0 \leq \alpha < 0.5 \\
N+1, & 0.5 \leq \alpha < 1 \\
N, & \alpha = 0.5, N\text{ even} \\
N+1, & \alpha = 0.5, N\text{ odd}
\end{cases}
\]

For example, 1.5 is rounded to 2, and 2.5 to 2.

Some image processing functions have additional rounding modes, which are set by the parameter `roundMode`.

### Integer Result Scaling

The default for image processing functions is to saturate the results without scaling them.

Some image processing functions operating on integer data use scaling of the internally computed output results by the integer `scaleFactor`, which is specified as one of the function parameters. These functions have the `Sfs descriptor in their names.

The scale factor can be negative, positive, or zero. Scaling is applied because internal computations are generally performed with a higher precision than the data types used for input and output images.

**NOTE**

The result of integer operations is always saturated to the destination data type range even when scaling is used.

The scaling of an integer result is done by multiplying the output pixel values by $2^{-\text{scaleFactor}}$ before the function returns. This helps retain either the output data range or its precision. Usually the scaling with a positive factor is performed by the shift operation. The result is rounded off to the nearest even integer number (see **Rounding Mode**).
For example, the integer result of the square operation for the input value 200 is equal to 32767 instead of 40000, that is, the result is saturated and the exact value cannot be restored. The scaling of the output value with the factor yields the result 20000, which is not saturated, and the exact value can be restored as 20000*2. Thus, the output data range is retained.

The following example shows how the precision can be partially retained by means of scaling. The integer square root operation (without scaling) for the input value 2 gives the result equal to 1.414. Scaling of the internally computed output value with the factor gives the result 11, and permits the more precise value to be restored as 11*2^3 = 1.375.

Error Reporting

The Intel IPP functions return status codes of the performed operation to report errors and warnings to the calling program. Thus, it is up to the application to perform error-related actions and/or recover from the error. The last value of the error status is not stored, and the user is to decide whether to check it or not as the function returns. The status codes are of type and are global constant integers.

The status codes and corresponding messages reported by Intel IPP for image and video processing are listed in Table.

### Status Codes and Messages

<table>
<thead>
<tr>
<th>Status Code</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNotSupportedModeErr</td>
<td>The requested mode is currently not supported.</td>
</tr>
<tr>
<td>ippStsDecimateFractionErr</td>
<td>Unsupported fraction in decimate.</td>
</tr>
<tr>
<td>ippStsWeightErr</td>
<td>Incorrect value for weight.</td>
</tr>
<tr>
<td>ippStsQualityIndexPath</td>
<td>Quality Index cannot be calculated for an image filled with a constant.</td>
</tr>
<tr>
<td>ippStsResizeNoOperationErr</td>
<td>One of the output image dimensions is less than 1 pixel.</td>
</tr>
<tr>
<td>ippStsBlockStepErr</td>
<td>Step for Block is less than 8.</td>
</tr>
<tr>
<td>ippStsMBStepErr</td>
<td>Step for MB is less than 16.</td>
</tr>
<tr>
<td>ippStsNoiseRangeErr</td>
<td>Noise value for Wiener Filter is out of range.</td>
</tr>
<tr>
<td>ippStsLPCcalcErr</td>
<td>Cannot evaluate linear prediction.</td>
</tr>
<tr>
<td>ippStsJPEG2KBadPassNumber</td>
<td>Pass number exceeds the limits of [0,nOfPasses-1].</td>
</tr>
<tr>
<td>ippStsJPEG2KDecodedCodeBlock</td>
<td>Codeblock for decoding is damaged.</td>
</tr>
<tr>
<td>ippStsH263CBPYCodeErr</td>
<td>Illegal Huffman code is detected during CBPY stream processing.</td>
</tr>
<tr>
<td>ippStsH263MCBPCInterCodeErr</td>
<td>Illegal Huffman code is detected during MCBPC Inter stream processing.</td>
</tr>
<tr>
<td>ippStsH263MCBPCIntraCodeErr</td>
<td>Illegal Huffman code is detected during MCBPC Intra stream processing.</td>
</tr>
<tr>
<td>ippStsNotEvenStepErr</td>
<td>Step value is not pixel multiple.</td>
</tr>
<tr>
<td>ippStsHistoNnofLevelsErr</td>
<td>Number of levels for histogram is less than 2.</td>
</tr>
<tr>
<td>ippStsLUTNnofLevelsErr</td>
<td>Number of levels for LUT is less than 2.</td>
</tr>
<tr>
<td>ippStsMP4BitOffsetErr</td>
<td>Incorrect value for bit offset.</td>
</tr>
<tr>
<td>ippStsMP4QPErr</td>
<td>Incorrect value for quantization parameter.</td>
</tr>
<tr>
<td>ippStsMP4BlockIdxErr</td>
<td>Incorrect value for block index.</td>
</tr>
<tr>
<td>ippStsMP4BlockTypeErr</td>
<td>Incorrect block type.</td>
</tr>
<tr>
<td>ippStsMP4MCVCodeErr</td>
<td>Illegal Huffman code is detected during MV stream processing.</td>
</tr>
<tr>
<td>ippStsMP4VLCCodeErr</td>
<td>Illegal Huffman code is detected during VLC stream processing.</td>
</tr>
<tr>
<td>ippStsMP4DCCodeErr</td>
<td>Illegal code is detected during DC stream processing.</td>
</tr>
<tr>
<td>ippStsMP4FcodeErr</td>
<td>Incorrect value for fcode.</td>
</tr>
<tr>
<td>ippStsMP4AlignErr</td>
<td>Incorrect buffer alignment.</td>
</tr>
<tr>
<td>ippStsMP4TempDiffErr</td>
<td>Incorrect temporal difference.</td>
</tr>
<tr>
<td>ippStsMP4BlockSizeErr</td>
<td>Incorrect size of block or macroblock.</td>
</tr>
<tr>
<td>ippStsMP4ZeroBABErr</td>
<td>All BAB values are equal to zero.</td>
</tr>
<tr>
<td>ippStsMP4PredDirErr</td>
<td>Incorrect prediction direction.</td>
</tr>
<tr>
<td>Status Code</td>
<td>Message</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>ippStsMP4BitsPerPixelErr</td>
<td>Incorrect number of bits per pixel.</td>
</tr>
<tr>
<td>ippStsMP4VideoCompModeErr</td>
<td>Incorrect video component mode.</td>
</tr>
<tr>
<td>ippStsMP4LinearModeErr</td>
<td>Incorrect DC linear mode.</td>
</tr>
<tr>
<td>ippStsH263PredModeErr</td>
<td>Incorrect value for Prediction Mode.</td>
</tr>
<tr>
<td>ippStsH263BlockStepErr</td>
<td>The step value is less than 8.</td>
</tr>
<tr>
<td>ippStsH263MBStepErr</td>
<td>The step value is less than 16.</td>
</tr>
<tr>
<td>ippStsH263FrameWidthErr</td>
<td>The frame width is less than 8.</td>
</tr>
<tr>
<td>ippStsH263FrameHeightErr</td>
<td>The frame height is less than, or equal to zero.</td>
</tr>
<tr>
<td>ippStsH263ExpandPelsErr</td>
<td>The expand pixels number is less than 8.</td>
</tr>
<tr>
<td>ippStsH263PlaneStepErr</td>
<td>Step value is less than the plane width.</td>
</tr>
<tr>
<td>ippStsH263QuantErr</td>
<td>Quantizer value is less than, or equal to zero, or more than 31.</td>
</tr>
<tr>
<td>ippStsH263MVCCodeErr</td>
<td>Illegal Huffman code is detected during MV stream processing.</td>
</tr>
<tr>
<td>ippStsH263VLCCodeErr</td>
<td>Illegal Huffman code is detected during VLC stream processing.</td>
</tr>
<tr>
<td>ippStsH263DCCodeErr</td>
<td>Illegal code is detected during DC stream processing.</td>
</tr>
<tr>
<td>ippStsH263ZigzagLenErr</td>
<td>Zigzag compact length is more than 64.</td>
</tr>
<tr>
<td>ippStsJPEGHuffTableErr</td>
<td>JPEG Huffman table is destroyed.</td>
</tr>
<tr>
<td>ippStsJPEGDCTRangeErr</td>
<td>JPEG DCT coefficient is out of range.</td>
</tr>
<tr>
<td>ippStsJPEGOutOfBufErr</td>
<td>An attempt to access out of the buffer.</td>
</tr>
<tr>
<td>ippStsChannelOrderErr</td>
<td>Incorrect order of the destination channels.</td>
</tr>
<tr>
<td>ippStsZeroMaskValueErr</td>
<td>All values of the mask are equal to zero.</td>
</tr>
<tr>
<td>ippStsRangeErr</td>
<td>Incorrect values for bounds: the lower bound is greater than the upper bound.</td>
</tr>
<tr>
<td>ippStsQPErr</td>
<td>Incorrect value for a quantizer parameter.</td>
</tr>
<tr>
<td>ippStsQuadErr</td>
<td>The quadrangle is nonconvex or degenerates into triangle, line, or point.</td>
</tr>
<tr>
<td>ippStsRectErr</td>
<td>Size of the rectangular region is less than, or equal to 1.</td>
</tr>
<tr>
<td>ippStsCoeffErr</td>
<td>Incorrect values for the transformation coefficients.</td>
</tr>
<tr>
<td>ippStsNoiseValErr</td>
<td>Incorrect value for the noise amplitude for dithering.</td>
</tr>
<tr>
<td>ippStsDitherLevelsErr</td>
<td>Number of dithering levels is out of range.</td>
</tr>
<tr>
<td>ippStsNumChannelsErr</td>
<td>Incorrect or unsupported number of channels.</td>
</tr>
<tr>
<td>ippStsDataTypeErr</td>
<td>Incorrect or unsupported data type.</td>
</tr>
<tr>
<td>ippStsCOIErr</td>
<td>COI is out of range.</td>
</tr>
<tr>
<td>ippStsOutOfRangeErr</td>
<td>Argument is out of range or point is outside the image.</td>
</tr>
<tr>
<td>ippStsDivisorErr</td>
<td>Divisor is equal to zero, function is aborted.</td>
</tr>
<tr>
<td>ippStsAlphaTypeErr</td>
<td>Illegal type of image composition operation.</td>
</tr>
<tr>
<td>ippStsGammaRangeErr</td>
<td>Gamma range bound is less than, or equal to zero.</td>
</tr>
<tr>
<td>ippStsGrayCoefSumErr</td>
<td>Sum of the conversion coefficients must be less than, or equal to 1.</td>
</tr>
<tr>
<td>ippStsChannelErr</td>
<td>Illegal channel number.</td>
</tr>
<tr>
<td>ippStsJaehneErr</td>
<td>Magnitude value is negative.</td>
</tr>
<tr>
<td>ippStsStepErr</td>
<td>Step value is less than, or equal to zero.</td>
</tr>
<tr>
<td>ippStsStrideErr</td>
<td>Stride value is less than the row length.</td>
</tr>
<tr>
<td>ippStsEpsValErr</td>
<td>Negative epsilon value.</td>
</tr>
<tr>
<td>ippStsScaleRangeErr</td>
<td>Scale bounds are out of range.</td>
</tr>
<tr>
<td>ippStsThresholdErr</td>
<td>Invalid threshold bounds.</td>
</tr>
<tr>
<td>ippStsWtOffsetErr</td>
<td>Invalid offset value for the wavelet filter.</td>
</tr>
<tr>
<td>ippStsAnchorErr</td>
<td>Anchor point is outside the mask.</td>
</tr>
<tr>
<td>ippStsMaskSizeErr</td>
<td>Invalid mask size.</td>
</tr>
<tr>
<td>ippStsShiftErr</td>
<td>Shift value is less than zero.</td>
</tr>
<tr>
<td>ippStsSampleFactorErr</td>
<td>Sampling factor is less than, or equal to zero.</td>
</tr>
<tr>
<td>ippStsResizeFactorErr</td>
<td>Resize factor(s) is less than, or equal to zero.</td>
</tr>
<tr>
<td>Status Code</td>
<td>Message</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>ippStsDivByZeroErr</td>
<td>An attempt to divide by zero.</td>
</tr>
<tr>
<td>ippStsInterpolationErr</td>
<td>Invalid interpolation mode.</td>
</tr>
<tr>
<td>ippStsMirrorFlipErr</td>
<td>Invalid flip mode.</td>
</tr>
<tr>
<td>ippStsMoment00ZeroErr</td>
<td>Moment value M(0,0) is too small to continue calculations.</td>
</tr>
<tr>
<td>ippStsThresholdNegLevelErr</td>
<td>Negative value of the level in the threshold operation.</td>
</tr>
<tr>
<td>ippStsContextMatchErr</td>
<td>Context parameter does not match the operation.</td>
</tr>
<tr>
<td>ippStsFFTFlagErr</td>
<td>Invalid value of the FFT flag parameter.</td>
</tr>
<tr>
<td>ippStsFFTOrderErr</td>
<td>Invalid value of the FFT order parameter.</td>
</tr>
<tr>
<td>ippStsMemAllocErr</td>
<td>Not enough memory for the operation.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Pointer is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Wrong value for the data size.</td>
</tr>
<tr>
<td>ippStsBadArgErr</td>
<td>Invalid or bad argument.</td>
</tr>
<tr>
<td>ippStsNoErr</td>
<td>No errors.</td>
</tr>
<tr>
<td>ippStsNoOperation</td>
<td>No operation has been executed.</td>
</tr>
<tr>
<td>ippStsMisalignedBuf</td>
<td>Misaligned pointer in operation in which it must be aligned.</td>
</tr>
<tr>
<td>ippStsSqrtNegArg</td>
<td>Negative value(s) of the argument in the function Sqrt.</td>
</tr>
<tr>
<td>ippStsInvZero</td>
<td>INF result. Zero value was met by InvThresh with zero level.</td>
</tr>
<tr>
<td>ippStsEvenMedianMaskSize</td>
<td>Even size of the Median Filter mask was replaced by the odd number.</td>
</tr>
<tr>
<td>ippStsDivByZero</td>
<td>Zero value(s) of the divisor in the function Div.</td>
</tr>
<tr>
<td>ippStsLnZeroArg</td>
<td>Zero value(s) of the argument in the function Ln.</td>
</tr>
<tr>
<td>ippStsLnNegArg</td>
<td>Negative value(s) of the argument in the function Ln.</td>
</tr>
<tr>
<td>ippStsNaNArg</td>
<td>Argument value is not a number.</td>
</tr>
<tr>
<td>ippStsDoubleSize</td>
<td>Sizes of image are not multiples of 2.</td>
</tr>
<tr>
<td>ippStsJPEGMarker</td>
<td>JPEG marker in the bitstream.</td>
</tr>
<tr>
<td>ippStsResFloor</td>
<td>All result values are floored.</td>
</tr>
<tr>
<td>ippStsWrongIntersectROI</td>
<td>Incorrect ROI that has no intersection with the source or destination</td>
</tr>
<tr>
<td></td>
<td>image. No operation.</td>
</tr>
<tr>
<td>ippStsWrongIntersectQuad</td>
<td>Incorrect quadrangle that has no intersection with the source or</td>
</tr>
<tr>
<td></td>
<td>destination ROI. No operation.</td>
</tr>
<tr>
<td>ippStsSymKernelExpected</td>
<td>The kernel is not symmetric.</td>
</tr>
<tr>
<td>ippStsEvenMedianWeight</td>
<td>Even weight of the Weighted Median Filter was replaced by the odd one.</td>
</tr>
<tr>
<td>ippStsNoAntialiasing</td>
<td>The mode does not support antialiasing.</td>
</tr>
<tr>
<td>ippStsAlgTypeErr</td>
<td>The algorithm type is not supported.</td>
</tr>
<tr>
<td>ippStsAccurateModeNotSupported</td>
<td>Accurate mode is not supported.</td>
</tr>
</tbody>
</table>

The status codes ending with *Err* (except for the ippStsNoErr status) indicate an error; the integer values of these codes are negative. When an error occurs, the function execution is interrupted.

The status code ippStsNoErr indicates no error. All other status codes indicate warnings. When a specific case is encountered, the function execution is completed and the corresponding warning status is returned. For example, if the functionippiDiv meets an attempt to divide a positive value by zero, the function execution is not aborted. The result of the operation is set to the maximum value that can be represented by the source data type, and the user is warned by the output status ippStsDivByZero. See appendix A Handling of Special Cases for more information.

**Platform-Aware Functions for Image Processing**

Intel® Integrated Performance Primitives (Intel® IPP) library provides so-called platform-aware functions. These functions use the special data type ippSizeL for object sizes. The ippSizeL data type represents memory-related quantities: it can be 32- or 64-bit wide depending on the target architecture.
While the rest of Intel IPP functions support only objects of 32-bit integer size, platform-aware functions can work with 64-bit object sizes if it is supported by the platform. The API of platform-aware functions is similar to the API of other Intel IPP functions and has only slight differences. You can distinguish platform-aware functions by the L suffix in the function name, for example,ippiAdd_8u_C1RSfs_L.

Currently, the following image processing functions have platform-aware APIs:

<table>
<thead>
<tr>
<th>Function Group</th>
<th>Header</th>
<th>Function Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arithmetic Functions</td>
<td>ippi.h/ippi_l.h</td>
<td>Add, AddC, Sub, SubC, Mul, MulC, Div</td>
</tr>
<tr>
<td>Linear Filters</td>
<td>ippi.h/ippi_l.h</td>
<td>FilterBilateralBorderGetSize</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FilterBilateralBorderInit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FilterBilateralBorder</td>
</tr>
<tr>
<td>Resize Transform Functionsippi.h/ippi_l.h</td>
<td>ResizeGetSize</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ResizeGetBufferSize</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ResizeGetBorderSize</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resize(Nearest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resize(Nearest</td>
</tr>
<tr>
<td>Support Functions</td>
<td>ippi.h/ippi_l.h</td>
<td>Malloc</td>
</tr>
</tbody>
</table>

Intel IPP platform-aware functions are documented as additional flavors to the existing functions declared in standard Intel IPP headers (without the l suffix). The ippi_l.h header is included into ippi.h.

**Threading Layer Functions**

Intel® Integrated Performance Primitives (Intel® IPP) library provides threading layer (TL) functions for image processing. It is a set of functions that are implemented as wrappers over Intel IPP platform-aware functions by using tiling and multithreading with OpenMP®. For implementation details, please see the corresponding source code files.

The API of TL functions is similar to the API of other Intel IPP functions and has only slight differences. You can distinguish Intel IPP TL functions by the _LT or _T suffix in the function name, for example,ippiAdd_8u_C1RSfs_LT. See Extensions for more information about function naming.

For more information about the TL functions usage, refer to the Intel IPP Developer Guide.

**Optimization Notice**

Intel's compilers may or may not optimize to the same degree for non-Intel microprocessors for optimizations that are not unique to Intel microprocessors. These optimizations include SSE2, SSE3, and SSSE3 instruction sets and other optimizations. Intel does not guarantee the availability, functionality, or effectiveness of any optimization on microprocessors not manufactured by Intel. Microprocessor-dependent optimizations in this product are intended for use with Intel microprocessors. Certain optimizations not specific to Intel microarchitecture are reserved for Intel microprocessors. Please refer to the applicable product User and Reference Guides for more information regarding the specific instruction sets covered by this notice.

Notice revision #20110804

Currently, the following image processing functions have TL APIs:
### Structures and Enumerators

This section describes the structures and enumerators used by the Intel Integrated Performance Primitives for image processing.

The `IppStatus` constant enumerates the status code values returned by Intel IPP functions, indicating whether the operation was error-free or not.

See section Error Reporting in this chapter for more information on the set of valid status codes and corresponding error messages for image and video processing functions.

The structure `IppiPoint` for storing the geometric position of a point is defined as

```c
typedef struct {
    int x;
    int y;
} IppiPoint;
```

where `x`, `y` denote the coordinates of the point.

---

<table>
<thead>
<tr>
<th>Function Group</th>
<th>Header</th>
<th>Function Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arithmetic Functions</td>
<td>ippi_tl.h</td>
<td>Add, AddC, Sub, SubC, Mul, MulC, Div, DivC</td>
</tr>
<tr>
<td>Filters</td>
<td>ippi_tl.h</td>
<td>FilterBilateralBorderGetSize, FilterBilateralBorderInit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FilterBilateralBorder, FilterBilateralGetBufferSize, FilterBilateralInit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FilterBilateral, FilterBorderGetSize, FilterBorderInit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FilterBorder, FilterMedianGetSize, FilterMedianInit</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FilterMedian</td>
</tr>
<tr>
<td>Resize Functions</td>
<td>ippi_tl.h</td>
<td>ResizeGetSize, ResizeGetBufferSize, ResizeGetBorderSize</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resize{Nearest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Resize{Nearest</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ResizeAntialiasing{Linear</td>
</tr>
<tr>
<td>Color Conversion Functions</td>
<td>ippcc_tl.h</td>
<td>RGBToLab, LabToRGB</td>
</tr>
</tbody>
</table>
The structure `IppPointPolar` for storing the geometric position of a point in polar coordinates is defined as

```
typedef struct {
    Ipp32f rho;
    Ipp32f theta;
} IppPointPolar;
```

where `rho` - a radial coordinate (radial distance from the origin), `theta` - an angular coordinate (counterclockwise angle from the `x`-axis).

The structure `IppiSize` for storing the size of a rectangle is defined as

```
typedef struct {
    int width;
    int height;
} IppSize;
```

where `width` and `height` denote the dimensions of the rectangle in the `x`- and `y`-directions, respectively.

The structure `IppiRect` for storing the geometric position and size of a rectangle is defined as

```
typedef struct {
    int x;
    int y;
    int width;
    int height;
} IppiRect;
```

where `x`, `y` denote the coordinates of the top left corner of the rectangle that has dimensions `width` in the `x`-direction by `height` in the `y`-direction.

The `ippiConnectedComp` structure used in Computer Vision functions defines the connected component as follows:

```
typedef struct _IppiConnectedComp {
    Ipp64f area;
    Ipp64f value[3];
    IppiRect rect;
} IppiConnectedComp;
```

where `area` - area of the segmented component; `value[3]` - gray scale value of the segmented component; `rect` - bounding rectangle of the segmented component.

The `IppiMaskSize` enumeration defines the neighborhood area for some morphological and filtering functions:

```
typedef enum {
    ippMskSize1x3 = 13,
    ippMskSize1x5 = 15,
    ippMskSize3x1 = 31,
    ippMskSize3x3 = 33,
    ippMskSize5x1 = 51,
    ippMskSize5x5 = 55
} IppiMaskSize;
```
The `IppCmpOp` enumeration defines the type of compare operation to be used in image comparison functions:

```c
typedef enum {
    ippCmpLess,
    ippCmpLessEq,
    ippCmpEq,
    ippCmpGreaterEq,
    ippCmpGreater
} IppCmpOp;
```

The `IppRoundMode` enumeration defines the rounding mode to be used in some conversion, filtering and arithmetic functions:

```c
typedef enum {
    ippRndZero,
    ippRndNear,
    ippRndFinancial,
    ippRndHintAccurate=0x10
} IppRoundMode;
```

The `IppHintAlgorithm` enumeration defines the type of code to be used in some image transform and statistics functions, that is, faster but less accurate, or vice-versa, more accurate but slower. For more information on using this enumerator, see Table Hint Arguments for Image Moment Functions.

```c
typedef enum {
    ippAlgHintNone,
    ippAlgHintFast,
    ippAlgHintAccurate
} IppHintAlgorithm;
```

The types of interpolation used by geometric transform functions are defined as follows:

```c
enum {
    IPPI_INTER_NN        = 1,
    IPPI_INTER_LINEAR    = 2,
    IPPI_INTER_CUBIC     = 4,
    IPPI_INTER_CUBIC2P_BSPLINE,
    IPPI_INTER_CUBIC2P_CATMULLROM,
    IPPI_INTER_CUBIC2P_B05C03,
    IPPI_INTER_SUPER     = 8,
    IPPI_INTER_LANCZOS   = 16,
    IPPI_ANTIALIASING    =(1 << 29)
    IPPI_SUBPIXEL_EDGE   =(1 << 30)
    IPPI_SMOOTH_EDGE     = IPP_MIN_32S
};
```

The `IppiAlphaType` enumeration defines the type of the compositing operation to be used in the alpha composition functions:

```c
typedef enum {
    ippAlphaOver,
    ippAlphaIn,
    ippAlphaOut,
    ippAlphaATop,
    ippAlphaXor,
    ippAlphaPlus,
};
```
ippAlphaOverPremul,
ippAlphaInPremul,
ippAlphaOutPremul,
ippAlphaATopPremul,
ippAlphaXorPremul,
ippAlphaPlusPremul
} IppiAlphaType;

The **IppiDitherType** enumeration defines the type of dithering to be used by the **ippiReduceBits** function:

```c
typedef enum {
    ippDitherNone,
    ippDitherFS,
    ippDitherJJN,
    ippDitherStucki,
    ippDitherBayer
} IppiDitherType;
```

The layout of the image slices used in some **image format conversion functions** is defined as follows:

```c
enum {
    IPP_UPPER        = 1,
    IPP_LEFT         = 2,
    IPP_CENTER       = 4,
    IPP_RIGHT        = 8,
    IPP_LOWER        = 16,
    IPP_UPPER_LEFT   = 32,
    IPP_UPPER_RIGHT  = 64,
    IPP_LOWER_LEFT   = 128,
    IPP_LOWER_RIGHT  = 256
};
```

The **IppiAxis** enumeration defines the flip axes for the **ippiMirror** functions or direction of the image intensity ramp for the **ippiImageRamp** functions:

```c
typedef enum {
    ippAxsHorizontal,
    ippAxsVertical,
    ippAxsBoth,
    ippAxs45,
    ippAxs135
} IppiAxis;
```

The **IppiBorderType** enumeration defines the border type that is used by some **Separable Filters** and **Fixed Filters** functions:

```c
typedef enum _IppiBorderType {
    ippBorderRepl      =  1,
    ippBorderWrap      =  2,
    ippBorderMirror    =  3,
    ippBorderMirrorR   =  4,
    ippBorderDefault   =  5,
    ippBorderConst     =  6,
    ippBorderTransp    =  7,
};
```
The **IppiFraction** enumeration defines shapes of the structuring element used in some decimate filter functions:

```c
typedef enum {
    ippPolyphase_1_2,
    ippPolyphase_3_5,
    ippPolyphase_2_3,
    ippPolyphase_7_10,
    ippPolyphase_3_4,
} IppiFraction;
```

The **IppiNormOp** enumeration defines the type of normalization that should be applied to the output data:

```c
typedef enum {
    ippiNormNone = 0x00000000, // default
    ippiNorm = 0x00000100, // normalized form
    ippiNormCoefficient = 0x00000200, // correlation coefficient in the range [-1.0,..,1.0]
    ippiNormMask = 0x0000FF00,
} IppiNormOp;
```

The **IppiROIShape** enumeration defines the window shape for the two-dimensional convolution-specific functions:

```c
typedef enum {
    ippiROIFull = 0x00000000,
    ippiROIValid = 0x00010000,
    ippiROISame = 0x00020000,
    ippiROIValid = 0x00FF0000
} IppiROIShape;
```

The **IppNormType** enumeration defines the norm type that should be applied when computing the magnitude of the gradient:

```c
typedef enum {
    ippNormInf = 0x00000001, // Infinity norm
    ippNormL1 = 0x00000002, // L1 normalization
    ippNormL2 = 0x00000004 // L2 normalization
} IppNormType;
```

The **IppiHOGConfig** structure defines the configuration parameters for the HOG descriptor:

```c
typedef struct {
    int   cvCompatible;  /* openCV compatible output format */
    int   cellSize;      /* square cell size (pixels) */
    int   blockSize;     /* square block size (pixels) */
    int   blockStride;   /* block displacement (the same for x- and y- directions) */
    int   nbins;         /* required number of bins */
    Ipp32f  sigma;      /* gaussian factor of HOG block weights */
} IppiHOGConfig;
```
Ipp32f  l2thresh;   /* normalization factor */
IppiSize  winSize;   /* detection window size (pixels) */
} IppiHOGConfig;

The code flags used by the FastN functions are defined as follows:

enum {
    IPP_FASTN_ORIENTATION = 0x0001,
    IPP_FASTN_NMS         = 0x0002,
    IPP_FASTN_CIRCLE      = 0X0004,
    IPP_FASTN_SCORE_MODE0 = 0X0020
};

The IppiFastNSpec specification structure is used by the FastN function:

struct FastNSpec;
typedef struct FastNSpec IppiFastNSpec;

The IppiCornerFastN structure used by the FastN2DToVec function stores the destination vector of structures:

typedef struct _IppiCornerFastN {
    int    x;
    int    y;
    int    cornerType;
    int    orientation;
    float  angle;
    float  score;
} IppiCornerFastN;

The IppFGMModel structure contains parameters for the Gaussian mixture-based segmentation algorithm:

typedef struct 
{
    unsigned int   numFrames;   /* length of history */
    unsigned int   numGauss;    /* maximal number of gaussian components per pixel */
        /* (numGauss<=maxNumGauss) */
    Ipp32f  varInit;     /* initial value of variance for new gaussian component */
    Ipp32f  varMin;      /* minimal bound of variance */
    Ipp32f  varMax;      /* maximal bound of variance */
    Ipp32f  varWBRatio;  /* background threshold */
    Ipp32f  bckgThr;     /* background total weights sum threshold */
    Ipp32f  varNGRatio;  /* threshold for adding new gaussian component to list */
    Ipp32f  reduction;   /* speed of reduction non-active gaussian components */
    Ipp8u   shadowValue; /* returned shadow value */
    char    shadowFlag;  /* search shadows flag */
    Ipp32f  shadowRatio; /* shadow threshold */
} IppFGMModel

The IppiMorphMode enumerator defines modes for mask processing at the second stage of advanced morphology operations:

typedef enum {
    IPP_MORPH_DEFAULT      = 0x0000,
    IPP_MORPH_MASK_NO_FLIP = 0x0001,
} IppiMorphMode;

The IppChannels enumerator defines the number of channels in the image:

typedef enum {
    ippC0   = 0,
    ippC1   = 1,
    ippC2   = 2,
    ippC3   = 3,
    ippC4   = 4,
} IppChannels;
The `IppFilterBilateralType` enumerator defines the type of the bilateral filter that is used by some Filtering Functions:

```c
typedef enum {
   ippiFilterBilateralGauss = 100,
    ippFilterBilateralGaussFast = 101
} IppFilterBilateralType;
```

The `IppiWarpTransformType` enumerator defines the type of the warp transform for some Warp Functions with Prior Initialization:

```c
typedef enum {
    ippWarpAffine,
    ippWarpPerspective,
    ippWarpBilinear,
} IppiWarpTransformType;
```

The `IppiDistanceMethodType` structure stores the method of defining the difference in intensity between pixels. It is defines as:

```c
typedef enum {
    ippDistNormL1 = 0x00000002;
    ippDistNormL2 = 0x00000004;
} IppiDistanceMethodType;
```

**Structures for 3D Data Processing Functions**

The `ipprBorderType` enumeration defines the border type that is used by some 3D Data Processing Functions:

```c
typedef enum _IpprBorderType {
    ipprBorderRepl        = ippBorderRepl,
    ipprBorderConst       = ippBorderConst,
    /* Flags to use source image memory pixels from outside of the border in particular directions */
    ipprBorderInMemTop    = 0x0010,
    ipprBorderInMemBottom = 0x0020,
    ipprBorderInMemLeft   = 0x0040,
    ipprBorderInMemRight  = 0x0080,
    ipprBorderInMemFront  = 0x1000,
    ipprBorderInMemBack   = 0x2000,
    ipprBorderInMem      = ipprBorderInMemLeft|ipprBorderInMemTop|ipprBorderInMemRight|
    ipprBorderInMemBottom|ipprBorderInMemFront|ipprBorderInMemBack,
} IpprBorderType;
```
The IpprVolume structure stores the volume of a three-dimensional space. It is defined as:

```c
typedef struct {
    int width;
    int height;
    int depth;
} IpprVolume;
```

The IpprCuboid structure stores the volume of interest of a three-dimensional space. It is defined as:

```c
typedef struct {
    int x;
    int y;
    int z;
    int width;
    int height;
    int depth;
} IpprCuboid;
```

## Function Context Structures

Some Intel IPP functions use special structures to store function-specific (context) information. For example, the IppiFFTSpec structure stores twiddle factors and bit reverse indexes needed in computing the fast Fourier transform.

Two different kinds of structures are used: structures that are not modified during function operation - they have the suffix Spec in their names, and structures that are modified during operation - they have the suffix State in their names.

These context-related structures are not defined in the public headers, and their fields are not accessible. It was done because the function context interpretation is processor dependent. Thus, you may only use context-related functions and may not create a function context as an automatic variable.

## Structures and Enumerators for Platform-Aware Functions

This topic describes the structures and enumerators used by the Intel IPP platform-aware functions for image processing.

The IppiPointL structure stores the geometric position of a point. It is defined as:

```c
typedef struct {
    IppSizeL x;
    IppSizeL y;
} IppiPointL;
```

where \(x\), \(y\) denote the coordinates of the point.

The IppiSizeL structure stores the size of a rectangle. It is defined as:

```c
typedef struct {
    IppSizeL width;
    IppSizeL height;
} IppiSizeL;
```

where width and height denote the dimensions of the rectangle in the \(x\)- and \(y\)-directions, respectively.
The `IppiRectL` structure stores the geometric position and size of a rectangle. It is defined as:

```
typedef struct {
    IppSizeL x;
    IppSizeL y;
    IppSizeL width;
    IppSizeL height;
} IppiRectL;
```

where \(x, y\) denote the coordinates of the top left corner of the rectangle that has dimensions \(\text{width}\) in the \(x\)-direction by \(\text{height}\) in the \(y\)-direction.

The `IpprVolumeL` structure stores the volume of a three-dimensional space. It is defined as:

```
typedef struct {
    IppSizeL width;
    IppSizeL height;
    IppSizeL depth;
} IpprVolumeL;
```

where \(\text{width}\), \(\text{height}\), and \(\text{depth}\) denote the dimensions of the three-dimensional space.

The `IpprBorderType` enumerator defines the border type that is used by some 3D Data Processing Functions:

```
typedef enum _IpprBorderType {
    ipprBorderRepl        = ippBorderRepl,
    ipprBorderConst       = ippBorderConst,
    ipprBorderInMemTop     =  0x0010,
    ipprBorderInMemBottom  =  0x0020,
    ipprBorderInMemLeft    =  0x0040,
    ipprBorderInMemRight   =  0x0080,
    ipprBorderInMemFront   =  0x1000,
    ipprBorderInMemBack    =  0x2000
} IpprBorderType;
```

## Image Data Types and Ranges

The Intel IPP image processing functions support only absolute color images in which each pixel is represented by its channel intensities. The data storage for an image can be either pixel-oriented or plane-oriented (planar). For images in pixel order, all channel values for each pixel are clustered and stored consecutively, for example, RGBRGBRGB in case of an RGB image. The number of channels in a pixel-order image can be 1, 2, 3, or 4.

For images in planar order, all image data for each channel is stored contiguously followed by the next channel, for example, RRR...GGG...BBB.

Functions that operate on planar images are identified by the presence of \(\text{Pn}\) descriptor in their names. In this case, \(n\) pointers (one for each plane) may be specified.

The image data type is determined by the pixel depth in bits per channel, or bit depth. Bit depth for each channel can be 8, 16 or 32 and is included in the function name as one of these numbers (see Function Naming in this chapter for details). The data may be signed \((s)\), unsigned \((u)\), or floating-point real \((\ell)\). For some arithmetic and FFT/DFT functions, data in complex format \((sc\ or\ fc)\) can be used, where each channel value is represented by two numbers: real and imaginary part. All channels in an image must have the same data type.
For example, in an absolute color 24-bit RGB image, three consecutive bytes (24 bits) per pixel represent the three channel intensities in the pixel mode. This data type is identified in function names as the 8u_C3 descriptor, where 8u represents 8-bit unsigned data for each channel and C3 represents three channels.

Some functions operate with images in 16-bit packed RGB format (see RGB Image Formats in Chapter 6 for more details). In this case data of all 3 channels are represented as 16u data type.

For example, in an absolute color 16-bit packed RGB image, two consecutive bytes (16 bits) per pixel represent the three channel intensities in the pixel mode. This data type is identified in function names as the 16u_C3 descriptor, where 16u represents 16-bit unsigned data (not a bit depth) for all packed channels together and C3 stands for three channels.

If an alpha (opacity) channel is present in image data, the image must have four channels, with alpha channel being the last or the first one. This data type is indicated by the AC4 or A0C4 descriptors respectively. The presence of the alpha channel can modify the function's behavior. For such functions, Intel IPP provides versions with and without alpha. If an alpha channel is specified, the operation usually is not performed on that channel.

The range of values that can be represented by each data type lies between the lower and upper bounds. The following table lists data ranges and constant identifiers used in Intel IPP to denote the respective range bounds:

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Lower Bound</th>
<th>Identifier</th>
<th>Value</th>
<th>Upper Bound</th>
<th>Identifier</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>8s</td>
<td>IPP_MIN_8S</td>
<td>-128</td>
<td>IPP_MAX_8S</td>
<td>127</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8u</td>
<td>0</td>
<td>IPP_MAX_8U</td>
<td>255</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16s</td>
<td>IPP_MIN_16S</td>
<td>-32768</td>
<td>IPP_MAX_16S</td>
<td>32767</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16u</td>
<td>0</td>
<td>IPP_MAX_16U</td>
<td>65535</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32s</td>
<td>IPP_MIN_32S</td>
<td>-2^{31}</td>
<td>IPP_MAX_32S</td>
<td>2^{31}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32u</td>
<td>0</td>
<td>IPP_MAX_32U</td>
<td>2^{32}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32f†</td>
<td>IPP_MINABS_32F</td>
<td>1.175494351e^{-38}</td>
<td>IPP_MAXABS_32F</td>
<td>3.402823466e^{38}</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

† The range for absolute values

Major Operation Models

Most Intel IPP image processing functions perform identical and independent operations on all channels of the processed image except for alpha channel. It means that the same operation is applied to each channel, and the computed results do not depend on values of other channels. Some exceptions include the ippiFilterMedianColor function and color conversion functions, which process three channels together.

Intel IPP image processing functions can be divided by two major models of operation:

- **Point operations**: functions operate on one pixel to compute the result, for example, ippiAdd
- **Neighborhood operations**: functions operate on a group of pixels, for example, ippiFilterBox

See Also

FilterMedianColor Filters an image using a color median filter.
Add Adds pixel values of two images.
FilterBox Blurs an image using a simple box filter.
Neighborhood Operations

The result of a neighborhood operation is based on values of a certain group of pixels located near a given input pixel. The set of neighboring pixels is typically defined by a rectangular mask (or kernel) and anchor cell, specifying the mask alignment with respect to the position of the input pixel as shown in the following figure.

The anchor cell is a fixed cell within the kernel, which is used for positioning the kernel with respect to the currently processed pixel of the source image. The kernel is placed on the image in such a way that the anchor cell coincides with the input pixel. The anchor cell is specified by its coordinates \( \text{anchor.x} \) and \( \text{anchor.y} \) in the coordinate system associated with the top left corner of the kernel.

If position of the anchor cell is not specified explicitly in the function description, coordinates of the anchor are computed by the default formula:

\[
\text{anchor.x} = \frac{(\text{kernel.width}-1)}{2} \\
\text{anchor.y} = \frac{(\text{kernel.height}-1)}{2}
\]

where

\( \text{kernel.width} \) and \( \text{kernel.height} \) is the width and height of the filter kernel, respectively.

Regions of Interest in Intel IPP

Most Intel IPP image processing functions operate not only on entire images but also on image areas. Image region of interest (ROI) is a rectangular area that may be either some part of the image or the whole image.

The Intel IPP functions with ROI support have an \( \text{R} \) descriptor in their names. ROI of an image is defined by the size and offset from the image origin as shown in figure. The origin of an image is in the top left corner, with \( x \) values increasing from left to right and \( y \) values increasing downwards.
Both the source and destination images can have a ROI. In such cases the sizes of ROIs are assumed to be
the same while offsets may differ. Image processing is performed on data of the source ROI, and the results
are written to the destination ROI. In function call sequences, ROI is specified by:

- roiSize parameter of the IppiSize type
- pSrc and pDst pointers to the starts of source and destination ROI buffers
- srcStep and dstStep parameters that are equal to distances in bytes between the starting points of
  consecutive lines in source and destination images, respectively.

Thus, the srcStep and dstStep parameters set steps in bytes through image buffers to start processing a new
line in the ROI of an image.

The following code example illustrates the use of the dstStep parameter in function calls:

**Example**

IppStatus roi( void ) {
    Ipp8u x[8*3] = {0};
    IppiSize roiSize = {3,2};
    IppiPoint roiPoint = {2,1};
    /// place the pointer to the ROI start position
    return ippiSet_8u_C1R( 7, x+8*roiPoint.y+roiPoint.x, 8, roiSize );
}

The resulting image x contains the following data:

```
00 00 00 00 00 00 00 00
00 00 07 07 07 00 00 00
00 00 07 07 07 00 00 00
```

If ROI is present:

- source and destination images can have different sizes;
- lines may have padding at the end for aligning the line sizes;
- application must correctly define the pSrc, pDst, and roiSize parameters.

The pSrc and pDst parameters are the shifted pointers to the image data. For example, in case of ROI
operations on 3-bytes-per-pixel image data (8u_C3R), pSrc points to the start of the source ROI buffer and
can be interpreted as follows:

\[
pSrc = pSrcImg + 3 \times (srcImgSize.width \times srcRoiOffset.y + srcRoiOffset.x),
\]

where
Another example for operations on four-channel image of 32-bit floating point data type 32f_AC4:

\[ pSrc = (Ipp32f*)((Ipp8u*)pSrcImg + srcImgStep * srcRoiOffset.y + 4*SizeOf(Ipp32f)*srcRoiOffset.x). \]

In this example the multiplier 4 is used because the AC4 pixel consists of 4 values - R, G, B, A. Pointer type conversion is required as in Intel IPP all image steps are always in bytes, and it is not recommended to use step/SizeOf(Ipp32f) as in a general case step value may be not a multiple of 4.

For functions using ROI with a neighborhood, you should correctly use values of the pSrc and roiSize parameters. These functions assume that the points in the neighborhood exist and that therefore pSrc is almost never equal to pSrcImg. Figure Using ROI with Neighborhood illustrates the case when neighborhood pixels can fall outside the source image.

To ensure valid operation when image pixels are processed, the application should correctly define additional border pixels (see Borders in Neighborhood Operations).

**Warning**

If the required border pixels are not defined prior to calling neighborhood functions that attempt to process such pixels, you may get memory violation errors.

The following code example shows how to process an image with ROI:

**Example**

```c
IppStatus alignedLine( void ) {
    Ipp8u x[8*3] = {0};
```
IppiSize imgSize = {5,3};
/// The image is of size 5x3. Width 8 has been
/// chosen by the user to align every line of the image
return ippiSet_8u_C1R( 7, x, 8, imgSize);
}

The resulting image \( x \) contains the following data:

<p>| | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>07</td>
<td>07</td>
<td>07</td>
<td>07</td>
<td>00</td>
<td>00</td>
<td>00</td>
<td></td>
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</tr>
<tr>
<td>07</td>
<td>07</td>
<td>07</td>
<td>07</td>
<td>00</td>
<td>00</td>
<td>00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>07</td>
<td>07</td>
<td>07</td>
<td>07</td>
<td>00</td>
<td>00</td>
<td>00</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**See Also**

Borders in Neighborhood Operations

**Tiled Image Processing**

Intel IPP can process images composed from tiles, or tiled images.
Support Functions

This chapter describes the Intel® IPP support functions that are used to:

- retrieve information about the current Intel IPP software version
- get a brief explanation of the returned status codes
- allocate and free memory that is needed for the operation of other Intel IPP image and video processing functions
- execute Intel IPP Threading Layer service routines.

Version Information Function

This function returns the version number and other information about the active Intel IPP image processing software.

GetLibVersion

* Returns information about the used version of Intel IPP software for image processing. *

**Syntax**

```c
const IppLibraryVersion* ippiGetLibVersion(void);
```

**Include Files**

ipp.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Description**

This function returns a pointer to a static data structure IppLibraryVersion that contains information about the current version of Intel IPP for image processing. You need not release memory referenced by the returned pointer, as it points to a static variable. The following fields of the IppLibraryVersion structure are available:

- `major`: the major number of the current library version
- `minor`: the minor number of the current library version
- `majorBuild`: the number of builds of the major version
- `build`: current build number
- `Name`: the name of the current library version
- `Version`: the library version string
BuildDate

For example, if the library version is 9.0, build revision number is 49671, library name is ippIP AVX2, target CPU is processor with Intel® Advanced Vector Extensions 2 (Intel® AVX2) and build date is “Dec 7 2015”, then the fields in this structure are set as:

\[
\begin{align*}
\text{major} &= 9, \\
\text{minor} &= 0, \\
\text{Name} &= \text{"ippIP AVX2"}, \\
\text{Version} &= \text{"9.0.1 (r49671)"}, \\
\text{targetCpu[4]} &= \text{"h9"}, \\
\text{BuildDate} &= \text{"Dec 7 2015"}
\end{align*}
\]

**NOTE**
Each sub-library that is used in the image processing domain has its own similar function to retrieve information about the active library version. These functions are: ippiGetLibVersion, ippcvGetLibVersion, and ippccGetLibVersion. They are declared in the following header files: ippcore.h, ippcv.h, ippcc.h, respectively, and have the same interface as the above described function.

### Status Information Function

Use this function to get a brief description of the status code returned by the current Intel IPP software.

**ippGetStatusString**

*Translates a status code into a message.*

**Syntax**

```c
const char* ippGetStatusString(IppStatus StsCode);
```

**Include Files**

ippcore.h

**Parameters**

*StsCode*  
Code that indicates the status type (see Table 2-1)

**Description**

This function returns a pointer to the text string associated with a status code *StsCode*. Use this function to produce error and warning messages. The returned pointer is a pointer to an internal static buffer and needs not be released.

The status information function translates this code into the corresponding message *Null Pointer Error.*
Example
A code example below shows how to use the ippGetStatusString function. If you call an Intel IPP function, in this example ippiSet_8u_C1R, with a NULL pointer, it returns an error code -8.

```c
void statusInfo( void ) {
    IppSize roi = {0};
    IppStatus st = ippiSet_8u_C1R(3, 0, 0, roi);
    printf( " %d : %s\n", st, ippGetStatusString( st ));
}
```

Output:
-8, Null Pointer Error

Memory Allocation Functions
This section describes the Intel IPP functions that allocate aligned memory blocks for data of required type, or free previously allocated memory.

**NOTE**
The only function to free the memory allocated by any of these functions is ippiFree().

Malloc
*Allocates memory aligned to 64-byte boundary.*

Syntax
Case 1: Memory allocation for blocks of 32-bit sizes

```c
Ipp<datatype>* ippiMalloc_<mod>(int widthPixels, int heightPixels, int* pStepBytes);
```

Supported values for `mod`:

- 8u_C1
- 16u_C1
- 16s_C1
- 32s_C1
- 32f_C1
- 32sc_C1
- 32fc_C1
- 8u_C2
- 16u_C2
- 16s_C2
- 32s_C2
- 32f_C2
- 32sc_C2
- 32fc_C2
- 8u_C3
- 16u_C3
- 16s_C3
- 32s_C3
- 32f_C3
- 32sc_C3
- 32fc_C3
- 8u_C4
- 16u_C4
- 16s_C4
- 32s_C4
- 32f_C4
- 32sc_C4
- 32fc_C4
- 8u_AC4
- 16u_AC4
- 16s_AC4
- 32s_AC4
- 32f_AC4
- 32sc_AC4
- 32fc_AC4

Case 2: Memory allocation for platform-aware functions

```c
Ipp<datatype>* ippiMalloc_<mod>(IppSizeL widthPixels, IppSizeL heightPixels, IppSizeL* pStepBytes);
```

Supported values for `mod`:

- 8u_C1_L
- 16u_C1_L
- 16s_C1_L
- 32s_C1_L
- 32f_C1_L
- 32sc_C1_L
- 32fc_C1_L
- 8u_C2_L
- 16u_C2_L
- 16s_C2_L
- 32s_C2_L
- 32f_C2_L
- 32sc_C2_L
- 32fc_C2_L
- 8u_C3_L
- 16u_C3_L
- 16s_C3_L
- 32s_C3_L
- 32f_C3_L
- 32sc_C3_L
- 32fc_C3_L
- 8u_C4_L
- 16u_C4_L
- 16s_C4_L
- 32s_C4_L
- 32f_C4_L
- 32sc_C4_L
- 32fc_C4_L
Include Files

ippi.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

widthPixels Width of an image, in pixels.

heightPixels Height of an image, in pixels.

pStepBytes Pointer to the distance, in bytes, between the starting points of consecutive lines in the image

Description

This function allocates a memory block aligned to 64-byte boundary for elements of different data types. Every line of the image is aligned in accordance with the pStepBytes parameter, which is calculated by the Malloc function and returned for further use.

The function Malloc allocates one continuous memory block. Functions that operate on planar images require an array of separate pointers (IppType* plane[3]) to each plane as an input. In this case, you should call the Malloc function three times.

Example

The code example below demonstrates how to construct an array and set correct values to the pointers to use the allocated memory block with the Intel IPP functions operating on planar images. You need to specify pStepBytes for each plane. The example is given for the 8u data type.

```c
int stepBytes[3];
Ipp8u* plane[3];
plane[0] = ippiMalloc_8u_C1(widthPixels, heightPixels,
                           &stepBytes[0]);
plane[1] = ippiMalloc_8u_C1(widthPixels/2, heightPixels/2,
                           &stepBytes[1]);
plane[2] = ippiMalloc_8u_C1(widthPixels/2, heightPixels/2,
                           &stepBytes[2]);
```

Return Values

The return value of Malloc function is a pointer to an aligned memory block.

If no memory is available in the system, the NULL value is returned.

To free the allocated memory block, use the Free function.

**Free**

Frees memory allocated by the function ippiMalloc.
Syntax
void ippiFree(void* ptr);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
ptr Pointer to a memory block to be freed. This block must have been previously allocated by the function ippiMalloc.

Description
This function frees the aligned memory block allocated by the function ippiMalloc.

NOTE
The function ippiFree cannot be used to free memory allocated by standard functions like malloc or calloc, nor can the memory allocated by ippiMalloc be freed by free.

Threading Layer Functions
This section described the Intel IPP Threading Layer (TL) functions for image processing. For more information about the TL functions usage, refer to the Intel IPP Developer Guide.

SplitUniform2D
Splits an image into tiles.

Syntax
Case 1: Operation with TL functions based on the Platform Aware API
IppStatus ippiSplitUniform2D_LT(IppiSizeL roiSize, IppSizeL minItemNumber, IppiPointL* pSplit, IppiSizeL* pTileSize, IppiSizeL* pTailSize);

Case 2: Operation with TL functions based on the Classic API
IppStatus ippiSplitUniform2D_T(IppSize roiSize, int minItemNumber, IppiPoint* pSplit, IppiSize* pTileSize, IppiSize* pTailSize);

Include Files
ippi_tl.h

Parameters
roiSize Image ROI size.
minItemNumber Minimal size of a tile, in pixels.
**pSplit**
Number of split parts along x and y axes.

**pTileSize**
Size of a tile.

**pTailSize**
Size of the last corner tile.

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP).
This function splits an image into tiles.

**Return Values**

- **ippStsNoErr**
  Indicates no error.

- **ippStsNullPtrErr**
  Indicates an error condition when the `pSplit`, `pTileSize`, or `pTailSize` pointer is NULL.

- **ippStsSizeErr**
  Indicates an error condition when `minItemNumber` is less than zero.

**ParallelFor**
*Performs parallel iterations for a processing function.*

**Syntax**

**Case 1: Operation with TL functions based on the Platform Aware API**

```c
IppStatus ippParallelFor_LT(IppSizeL numTiles, void* arg, functype_l func);
```

**Case 2: Operation with TL functions based on the Classic API**

```c
IppStatus ippParallelFor_T(int numTiles, void* arg, functype func);
```

**Include Files**

- `ippcore_tl.h`

**Parameters**

- **numTiles**
  Number of tiles.

- **arg**
  Pointer to the structure that contains arguments for the processing function.

- **func**
  Pointer to the processing function used in the "parallel for" loop.

**Description**
This function performs parallel iterations of a processing function, which is passed as an argument for each tile.

**Return Values**

- **ippStsNoErr**
  Indicates no error.

  Any IPP error that the processing function can return.

**GetTilePointer**
*Returns a pointer to the specified image tile.*
Syntax

Case 1: Operation with TL functions based on the Platform Aware API

IppStatus ippiGetTilePointer_32f_LT(const Ipp32f* pSrc, Ipp32f** pDst, IppSizeL srcStep, IppSizeL x, IppSizeL y, Ipp32s numChannels);
IppStatus ippiGetTilePointer_64f_LT(const Ipp64f* pSrc, Ipp64f** pDst, IppSizeL srcStep, IppSizeL x, IppSizeL y, Ipp32s numChannels);

Case 2: Operation with TL functions based on the Classic API

IppStatus ippiGetTilePointer_32f_T(const Ipp32f* pSrc, Ipp32f** pDst, int srcStep, int x, int y, Ipp32s numChannels);
IppStatus ippiGetTilePointer_64f_T(const Ipp64f* pSrc, Ipp64f** pDst, int srcStep, int x, int y, Ipp32s numChannels);

Include Files

ippi_tl.h

Parameters

pSrc  
Pointer to the source image.

pDst  
Pointer to the memory location of the pointer to the destination image.

srcStep  
Distance in bytes between consecutive lines in the source image.

x  
x coordinate of a tile, in pixels.

y  
y coordinate of a tile, in pixels.

numChannels  
Number of channels in the image. Possible values are 1, 3, and 4.

Description

This function returns a pointer to the specified image tile.

Return Values

ippStsNoErr  
Indicates no error.

ippStsNullPtrErr  
Indicates an error condition when the pSrc or pDst pointer is NULL.

ippStsSizeErr  
Indicates an error condition when x or y is less than zero.

ippStsNumChannelsErr  
Indicates an error condition when numChannels has an illegal value.

GetTileParamsByIndex

Returns the offset and size of a tile by a given index.

Syntax

Case 1: Operation with TL functions based on the Platform Aware API

IppStatus ippiGetTileParamsByIndex_LT(IppSizeL index, IppPointL splitImage, IppSizeL tileSize, IppSizeL tailSize, IppPointL* pTileOffset, IppSizeL* pTileSize);
Case 2: Operation with TL functions based on the Classic API

IppStatus ippiGetTileParamsByIndex_T(int index, IppiPoint splitImage, IppiSize tileSize, IppiSize tailSize, IppiPoint* pTileOffset, IppiSize* pTileSize);

Include Files
ippi_tl.h

Parameters

index
Ordinal index of a tile.
splitImage
Split of the image by x and y axis correspondingly.
tileSize
Size of a tile.
tailSize
Size of the last bottom right tile.
pTileOffset
Offset of the tile corresponding to the top left image corner.
pTileSize
Size of a tile.

Description
This function returns the offset and size of a tile by a given index.

Return Values

ippStsNoErr
Indicates no error.
ippStsNullPtrErr
Indicates an error condition when the pTileOffset or pTileSize pointer is NULL.

GetThreadingType

Returns type of the threading layer.

Syntax

Case 1: Operation with TL functions based on the Platform Aware API

IppStatus ippGetThreadingType_LT(IppThreadingType* thrType);

Case 2: Operation with TL functions based on the Classic API

IppStatus ippGetThreadingType_T(IppThreadingType* thrType);

Include Files
ippi_core_tl.h

Parameters

thrType
Pointer to the threading type.

Description
This function returns OMP if the OpenMP* Threading Layer and TBB if the TBB* Threading Layer is used.

Return Values

ippStsNoErr
Indicates no error.
GetThreadIdx

Returns a unique thread identification number.

Syntax

**Case 1: Operation with TL functions based on the Platform Aware API**

IppStatus ippGetThreadIdx_LT(int* pThrIdx);

**Case 2: Operation with TL functions based on the Classic API**

IppStatus ippGetThreadIdx_T(int* pThrIdx);

Include Files

ippcore_tl.h

Parameters

*pThrIdx* 
 Pointer to the index of a thread.

Description

This function returns a unique thread identification number.

Return Values

<table>
<thead>
<tr>
<th>Status Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error condition when the <code>thrType</code> pointer is NULL.</td>
</tr>
</tbody>
</table>
Image Data Exchange and Initialization Functions

This chapter describes the Intel® IPP image processing functions that perform image data manipulation, exchange and initialization operations.

Convert

Converts image pixel values from one data type to another.

Syntax

Case 1: Conversion to increase bit depth and change signed to unsigned type

IppStatus ippiConvert_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

8u16u_C1R 8u16s_C1R 8u32s_C1R 8u32f_C1R 8s32s_C1R
8u16u_C3R 8u16s_C3R 8u32s_C3R 8u32f_C3R 8s32s_C3R
8u16u_C4R 8u16s_C4R 8u32s_C4R 8u32f_C4R 8s32s_C4R
8s32f_C1R 16u32s_C1R 16u32f_C1R 16s32s_C1R 16s32f_C1R
8s32f_C3R 16u32s_C3R 16u32f_C3R 16s32s_C3R 16s32f_C3R
8s32f_C4R 16u32s_C4R 16u32f_C4R 16s32s_C4R 16s32f_C4R
8s8u_C1Rs 16s16u_C1Rs 16u32u_C1Rs 32s32u_C1Rs 32s32f_C1R
8s16u_C1Rs 16s32u_C1Rs 32s32f_C1R
8s16s_C1R
8s16u_C1Rs
8s32u_C1Rs
8s64f_C1R

IppStatus ippiConvert_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

8u16u_AC4R 8u16s.AC4R 8u32s.AC4R 8u32f.AC4R 8s32s.AC4R
8s32f.AC4R 16u32s.AC4R 16u32f.AC4R 16s32s.AC4R 16s32f.AC4R

Case 2: Conversion to reduce bit depth and change unsigned to signed type: integer to integer type

IppStatus ippiConvert_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

16u8u_C1R 16s8u_C1R 32s8u_C1R 32s8s_C1R
16u8u_C3R 16s8u_C3R 32s8u_C3R 32s8s_C3R
16u8u_C4R 16s8u_C4R 32s8u_C4R 32s8s_C4R
IppStatus ippiConvert_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppSize roiSize, IppRoundMode roundMode, int scaleFactor);

**Supported values for mod:**

- 8u8s_C1RSfs
- 16u8s_C1RSfs
- 32u8s_C1RSfs
- 32s16u_C1RSfs
- 16s8u_C1RSfs
- 32u8s_C1RSfs
- 32s16s_C1RSfs
- 16u16s_C1RSfs
- 32u16s_C1RSfs
- 32u32s_C1RSfs

IppStatus ippiConvert_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppSize roiSize);

**Supported values for mod:**

- 16u8u_AC4R
- 16s8u_AC4R
- 32s8u_AC4R
- 32s8s_AC4R

**Floating point to integer type:**

IppStatus ippiConvert_<mod>(const Ipp32f* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppSize roiSize, IppRoundMode roundMode);

**Supported values for mod:**

- 32f8u_C1R
- 32f8s_C1R
- 32f16u_C1R
- 32f16s_C1R
- 32f8u_C3R
- 32f8s_C3R
- 32f16u_C3R
- 32f16s_C3R
- 32f8u_C4R
- 32f8s_C4R
- 32f16u_C4R
- 32f16s_C4R

IppStatus ippiConvert_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppSize roiSize, IppRoundMode roundMode, int scaleFactor);

**Supported values for mod:**

- 32f8u_C1RSfs
- 32f8s_C1RSfs
- 32f16u_C1RSfs
- 32f16s_C1RSfs
- 32f32u_C1RSfs
- 64f8u_C1RSfs
- 64f8s_C1RSfs
- 64f16u_C1RSfs
- 64f16s_C1RSfs
IppStatus ippiConvert_32f32u_C1IRSfs(Ipp32u* pSrcDst, int srcDstStep, IppiSize roiSize, IppRoundMode roundMode, int scaleFactor);

IppStatus ippiConvert_<mod>(const Ipp32f* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize roiSize, IppRoundMode roundMode);

Supported values for mod:
- 32f8u_AC4R
- 32f8s_AC4R
- 32f16u_AC4R
- 32f16s_AC4R

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc**
  Pointer to the source image ROI.

- **srcStep**
  Distance, in bytes, between the starting points of consecutive lines in the source image.

- **pDst**
  Pointer to the destination image ROI.

- **pSrcDst**
  Pointer to the source and destination image ROI for in-place operation.

- **dstStep**
  Distance, in bytes, between the starting points of consecutive lines in the destination image.

- **srcDstStep**
  Distance, in bytes, between the starting points of consecutive lines in the source and destination image for in-place operation.

- **roiSize**
  Size of the source and destination ROI in pixels.

- **scaleFactor**
  Scale factor (see Integer Result Scaling).

- **roundMode**
  Rounding mode, the following values are possible:
  - **ippRndZero**
    specifies that floating-point values are truncated to zero,
  - **ippRndNear**
    specifies that floating-point values are rounded to the nearest even integer when the fractional part equals 0.5; otherwise they are rounded to the nearest integer,
  - **ippRndFinancial**
    specifies that floating-point values are rounded down to the nearest integer when the fractional part is less than 0.5, or rounded up to the nearest integer if the fractional part is equal or greater than 0.5.
Description

This function operates with ROI.

This function converts pixel values in the source image ROI \textit{pSrc} to a different data type and writes them to the destination image ROI \textit{pDst}.

The result of integer operations is always saturated to the destination data type range. It means that if the value of the source pixel is out of the data range of the destination image, the value of the corresponding destination pixel is set to the value of the lower or upper bound (minimum or maximum) of the destination data range:

\begin{align*}
    x &= pSrc[i,j] \\
    \text{if } (x > \text{MAX\_VAL}) &\quad x = \text{MAX\_VAL} \\
    \text{if } (x < \text{MIN\_VAL}) &\quad x = \text{MIN\_VAL}
\end{align*}

\textit{pDst}[i,j] = \text{(CASTING)}x

If you want to shift data from the signed range to the unsigned range and vice-versa, see "Application Notes" below.

The function flavors with the \textit{Sfs} descriptor in their names perform scaling of the internally computed results in accordance with the \textit{scaleFactor} parameter.

When converting from floating-point to integer type, rounding defined by \textit{roundMode} is performed, and the result is saturated to the destination data type range.

\textbf{NOTE}

The bit order of each byte in the source image is inverse to the pixel order. It means that the first pixel in a row represents the last (seventh) bit of the first byte in a row.

Application Notes

When data is converted from the signed integer to the corresponding unsigned integer and vice versa (8s -- >8u, 16u --> 16s), the pixel information may be lost because all negative values will be set to zero (signed-unsigned conversion), or unsigned values from the high half of the range will be set to the maximum value of the signed range (unsigned - signed conversion).

If you need just to shift the data from the signed range to the unsigned range and vice versa, use the function \textit{ippiXorC} with the parameter \textit{value} specified in such a way that the most significant bit is set to 1, and all other bits are set to 0. For example, if you want to convert pixel values from \textit{Ipps16s} type to \textit{Ipp16u} type with the range shift call the function:

\texttt{ippiXorC	extunderscore 16u	extunderscore C1R((Ipp16u *)pSrc, srcStep, 0x8000, pDst, dstStep, roiSize);}

In this case the pixels values are converted as follows:

\begin{align*}
-32768 &\quad\rightarrow 0 \\
-32767 &\quad\rightarrow 1 \\
... \\
-1 &\quad\rightarrow 32767 \\
0 &\quad\rightarrow 32768 \\
1 &\quad\rightarrow 32769 \\
... \\
\end{align*}
Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when any of the specified pointers is `NULL`, with the exception of second mode in Case 4.
- **ippStsSizeErr**: Indicates an error when `roiSize` has a field with zero or negative value, or `srcBitOffset/dstBitOffset` is less than zero.
- **ippStsStepErr**: Indicates an error when `srcStep` or `dstStep` has a zero or negative value.
- **ippStsMemAllocErr**: Indicates an error when memory allocation fails.

Example

The code example below shows data conversion without scaling.

```c
IppStatus convert( void ) {
    IppiSize roi={5,4};
    Ipp32f x[5*4];
    Ipp8u y[5*4];
    ippiSet_32f_C1R( -1.0f, x, 5*sizeof(Ipp32f), roi );
    x[1] = 300; x[2] = 150;
    return ippiConvert_32f8u_C1R( x, 5*sizeof(Ipp32f), y, 5, roi, ippRndNear );
}
```

The destination image `y` contains:

```
00 FF 96 00 00
00 00 00 00 00
00 00 00 00 00
00 00 00 00 00
```

See Also

- Integer Result Scaling
- Regions of Interest in Intel IPP

**BinToGray, GrayToBin**

*Converts a bitonal image to a grayscale image and vice versa.*
**Syntax**

**Case 1: Conversion of a bitonal image to a grayscale image**

IppStatus ippiBinToGray_1u<dstDataType>_C1R(const Ipp8u* pSrc, int srcStep, int srcBitOffset, Ipp<dstDataType>* pDst, int dstStep, IppiSize roiSize, Ipp<dstDataType> loVal, Ipp<dstDataType> hiVal);

Supported values for dstDataType:

| 8u | 16u | 16s | 32f |

**Case 2: Conversion of a grayscale image to a bitonal image**

IppStatus ippiGrayToBin_<srcDataType>1u_C1R(const Ipp<srcDataType>* pSrc, int srcStep, Ipp8u* pDst, int dstStep, int dstBitOffset, IppiSize roiSize, Ipp<srcDataType> threshold);

Supported values for srcDataType:

| 8u | 16u | 16s | 32f |

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **pSrc**
  - Pointer to the source image ROI.
- **srcStep**
  - Distance, in bytes, between the starting points of consecutive lines in the source image.
- **srcBitOffset**
  - Offset, in bits, from the first byte of the source image row.
- **pDst**
  - Pointer to the destination image ROI.
- **dstStep**
  - Distance, in bytes, between the starting points of consecutive lines in the destination image.
- **dstBitOffset**
  - Offset, in bits, from the first byte of the destination image row.
- **roiSize**
  - Size of the ROI in pixels.
- **loVal**
  - Destination value that corresponds to the "0" value of the corresponding source element.
- **hiVal**
  - Destination value that corresponds to the "1" value of the corresponding source element.
- **threshold**
  - Threshold level.

**Description**

These functions operate with ROI.
The `ippiBinToGray` function converts a bitonal image to grayscale, and the `ippiGrayToBin` function converts a grayscale image to bitonal. The data type of the bitonal image is `8u`. It means that each byte consists of eight consecutive pixels of the image (1 bit per pixel). You need to specify the start position of the ROI buffer in the `srcBitOffset` and `dstBitOffset` parameters.

The `ippiBinToGray` function transforms each bit of the source image into the pixel of the destination image in the following way:

- If the input pixel is equal to 0, the corresponding output pixel is set to `loVal`.
- If the input pixel is equal to 1, the corresponding output pixel is set to `hiVal`.

The `ippiGrayToBin` function transforms each pixel of the source image into the bit of the destination image in the following way:

- If the input pixel is more than the `threshold` value, the corresponding output bit is set to 1.
- If the input pixel is less than, or equal to the `threshold` value, the corresponding output bit is set to 0.

**Return Values**

- `ippStsNoErr`: Indicates no error.
- `ippStsNullPtrErr`: Indicates an error when any of the specified pointers is `NULL`.
- `ippStsStepErr`: Indicates an error when the `srcStep` or `dstStep` value is less than, or equal to zero.
- `ippStsSizeErr`: Indicates an error when:
  - `roiSize` has a zero or negative value
  - the `srcBitOffset` or `dstBitOffset` value is less than zero

**See Also**

Regions of Interest in Intel IPP

**Scale**

*Scales pixel values of an image and converts them to another bit depth.*

**Syntax**

**Case 1: Scaling with conversion to integer data of increased bit depth**

```c
IppStatus ippiScale_<mod>(const Ipp<srcDatatype> *pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize roiSize);
```

Supported values for `mod`:

<table>
<thead>
<tr>
<th>srcDatatype</th>
<th>dstDatatype</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u16u_C1R</td>
<td>8u16s_C1R</td>
</tr>
<tr>
<td>8u16u_C3R</td>
<td>8u16s_C3R</td>
</tr>
<tr>
<td>8u16u_C4R</td>
<td>8u16s_C4R</td>
</tr>
</tbody>
</table>

```c
IppStatus ippiScale_<mod>(const Ipp<srcDatatype> *pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize roiSize);
```

Supported values for `mod`:

<table>
<thead>
<tr>
<th>srcDatatype</th>
<th>dstDatatype</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u16u_AC4R</td>
<td>8u16s_AC4R</td>
</tr>
<tr>
<td>8u32s_AC4R</td>
<td></td>
</tr>
</tbody>
</table>
**Case 2: Scaling with conversion to floating-point data**

IppStatus ippiScale_<mod>(const Ipp8u* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppSize roiSize, Ipp32f vMin, Ipp32f vMax);

Supported values for mod:

- 8u32f_C1R
- 8u32f_C3R
- 8u32f_C4R

IppStatus ippiScale_8u32f_AC4R(const Ipp8u* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppSize roiSize, Ipp32f vMin, Ipp32f vMax);

**Case 3: Scaling of integer data with conversion to reduced bit depth**

IppStatus ippiScale_<mod> (const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppSize roiSize, IppHintAlgorithm hint);

Supported values for mod:

- 16u8u_C1R
- 16u8u_C3R
- 16u8u_C4R
- 16s8u_C1R
- 16s8u_C3R
- 16s8u_C4R
- 32s8u_C1R
- 32s8u_C3R
- 32s8u_C4R

IppStatus ippiScale_<mod> (const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppSize roiSize, IppHintAlgorithm hint);

Supported values for mod:

- 16u8u_AC4R
- 16s8u_AC4R
- 32s8u_AC4R

**Case 4: Scaling of floating-point data with conversion to integer data type**

IppStatus ippiScale_<mod>(const Ipp32f* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppSize roiSize, Ipp32f vMin, Ipp32f vMax);

Supported values for mod:

- 32f8u_C1R
- 32f8u_C3R
- 32f8u_C4R

IppStatus ippiScale_32f8u_AC4R(const Ipp32f* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppSize roiSize, Ipp32f vMin, Ipp32f vMax);

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib
**Parameters**

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance, in bytes, between the starting points of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance, in bytes, between the starting bytes of consecutive lines in the destination image.
- **roiSize**: Size of the source and destination ROI in pixels.
- **vMin, vMax**: Minimum and maximum values of the input data.
- **hint**: Option to select the algorithmic implementation of the function (see Hint Arguments for Image Moment Functions).

**Description**

This function operates with ROI.

This function converts pixel values of a source image ROI \( pSrc \) to the destination data type, using a linear mapping. The computation algorithm is specified by the \( \text{hint} \) argument. For conversion between integer data types, the whole range \([\text{src\_Min}..\text{src\_Max}]\) of the input data type is mapped onto the range \([\text{dst\_Min}..\text{dst\_Max}]\) of the output data type.

The source pixel \( p \) is mapped to the destination pixel \( p' \) by the following formula:

\[
p' = \text{dst\_Min} + k \cdot (p - \text{src\_Min})
\]

where

\[
k = (\text{dst\_Max} - \text{dst\_Min})/(\text{src\_Max} - \text{src\_Min})
\]

For conversions to and from floating-point data type, the user-defined floating-point data range \([\text{vMin}..\text{vMax}]\) is mapped onto the source or destination data type range.

If the conversion is from \text{Ipp32f} type and some of the input floating-point values are outside the specified input data range \([\text{vMin}..\text{vMax}]\), the corresponding output values saturate. To determine the actual floating-point data range in your image, use the \text{ippiMinMax} function.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when any of the specified pointers is \text{NULL}.
- **ippStsSizeErr**: Indicates an error condition if \( \text{roiSize} \) has a field with a zero or negative value.
- **ippStsStepErr**: Indicates an error condition if \( \text{srcStep} \) or \( \text{dstStep} \) has a zero or negative value.
- **ippStsScaleRangeErr**: Indicates an error condition if the input data bounds are incorrect, that is, \( \text{vMax} \) is less than or equal to \( \text{vMin} \).
Example

The code example below shows how to use scaling to preserve the data range.

```c
IppStatus scale( void ) {
    IppSize roi = {5,4};
    Ipp32f x[5*4];
    Ipp8u y[5*4];
    ippiSet_32f_C1R( -1.0f, x, 5*sizeof(Ipp32f), roi );
    x[1] = 300; x[2] = 150;
    return ippiScale_32f8u_C1R( x, 5*sizeof(Ipp32f), y, 5, roi, -1, 300 );
}
```

The destination image $y$ contains:

```
00 FF 00 00 00
00 00 00 00 00
00 00 00 00 00
00 00 00 00 00
```

See Also

Regions of Interest in Intel IPP
Image Moments
Intel® Integrated Performance Primitives Concepts
MinMax Computes the minimum and maximum of image pixel values.

ScaleC

_Scales pixel values of an image and converts them to another bit depth._

Syntax

Case 1: Not-in-place operation

```c
IppStatus ippiScaleC_<mod>_C1R(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp64f mVal,
Ipp64f aVal, Ipp<dstDatatype>* pDst, int dstStep, IppiSize roiSize, IppHintAlgorithm hint);
```

Supported values for `mod`:

```
8u     8u8s    8u16u   8u16s   8u32s    8u32f    8u64f
8s8u   8s      8s16u   8s16s   8s32s   8s32f    8s64f
16u8u  16u8s   16u     16u16s  16u32s  16u32f   16u64f
16s8u  16s8s   16s16u  16s16s  16s32s  16s32f   16s64f
32s8u  32s8s   32s16u  32s16s  32s32s  32s32f   32s64f
32f8u  32f8s   32f16u  32f16s  32f32s  32f32f   32f64f
64f8u  64f8s   64f16u  64f16s  64f32s  64f32f   64f
```

Image Data Exchange and Initialization Functions
where the first value is \textit{srcDatatype} and the second value is \textit{dstDatatype}.

\textbf{Case 2: In-place operation}

\texttt{IppStatus ippiScaleC_<mod>_C1IR(const Ipp<datatype>* pSrcDst, int srcDstStep, Ipp64f mVal, Ipp64f aVal, IppiSize roiSize, IppHintAlgorithm hint);}

Supported values for mod:

<table>
<thead>
<tr>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u</td>
</tr>
<tr>
<td>8s</td>
</tr>
<tr>
<td>16u</td>
</tr>
<tr>
<td>16s</td>
</tr>
<tr>
<td>32s</td>
</tr>
<tr>
<td>32f</td>
</tr>
<tr>
<td>64f</td>
</tr>
</tbody>
</table>

\textbf{Include Files}

ippi.h

\textbf{Domain Dependencies}

\textbf{Headers:} ippcore.h, ippvm.h, ipps.h

\textbf{Libraries:} ippcore.lib, ippvm.lib, ipps.lib

\textbf{Parameters}

\texttt{pSrc}  
Pointer to the source image ROI.

\texttt{pSrcDst}  
Pointer to the source and destination buffer or an array of pointers to separate source and destination color planes for in-place operation.

\texttt{srcDstStep}  
Distance, in bytes, between the starting points of consecutive lines in the source and destination image for in-place operation.

\texttt{srcStep}  
Distance, in bytes, between the starting points of consecutive lines in the source image.

\texttt{mVal}  
Value of the multiplier used for scaling.

\texttt{aVal}  
Offset value for scaling.

\texttt{pDst}  
Pointer to the destination image ROI.

\texttt{dstStep}  
Distance, in bytes, between the starting bytes of consecutive lines in the destination image.

\texttt{roiSize}  
Size of the source and destination ROI, in pixels.

\texttt{hint}  
Option to select the algorithmic implementation of the function. Supported values are ippAlgHintFast (default) and ippAlgHintAccurate.

\textbf{Description}

This function operates with ROI (see Regions of Interest in Intel IPP).

This function scales pixel values of the source image ROI and converts them to the destination data type according to the following formula:

\[
dst = \text{saturate\_to\_dstType}(src \times mVal + aVal)
\]
Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr Indicates an error when any of the specified pointers is NULL.

ippStsSizeErr Indicates an error when roiSize has a field with a zero or negative value.

ippStsStepErr Indicates an error when the step value is less than, or equal to zero.

Example

To better understand usage of this function, refer to the ScaleC.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

See Also

Regions of Interest in Intel IPP

Set

Sets pixels of an array to a constant value.

Syntax

Case 1: Setting one-channel data to a value

IppStatus ippiSet_<mod>(Ipp<datatype> value, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

| 8u_C1R | 16u_C1R | 16s_C1R | 32s_C1R | 32f_C1R |

Case 2: Setting each color channel to a specified value

IppStatus ippiSet_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

| 8u_C3R | 16u_C3R | 16s_C3R | 32s_C3R | 32f_C3R |
| 8u_AC4R | 16u_AC4R | 16s_AC4R | 32s_AC4R | 32f_AC4R |

Case 3: Setting color channels and alpha channel to specified values

IppStatus ippiSet_<mod>(const Ipp<datatype> value[4], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

| 8u_C4R | 16u_C4R | 16s_C4R | 32s_C4R | 32f_C4R |
Case 4: Setting masked one-channel data to a value

IppStatus ippiSet_<mod>(Ipp<datatype> value, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp8u* pMask, int maskStep);

Supported values for mod:

| 8u_C1MR | 16u_C1MR | 16s_C1MR | 32s_C1MR | 32f_C1MR |

Case 5: Setting color channels of masked multi-channel data to specified values

IppStatus ippiSet_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp8u* pMask, int maskStep);

Supported values for mod:

| 8u_C3MR | 16u_C3MR | 16s_C3MR | 32s_C3MR | 32f_C3MR |
| 8u_AC4MR | 16u_AC4MR | 16s_AC4MR | 32s_AC4MR | 32f_AC4MR |

Case 6: Setting all channels of masked multi-channel data to specified values

IppStatus ippiSet_<mod>(const Ipp<datatype> value[4], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp8u* pMask, int maskStep);

Supported values for mod:

| 8u_C4MR | 16u_C4MR | 16s_C4MR | 32s_C4MR | 32f_C4MR |

Case 7: Setting selected channel of multi-channel data to a value

IppStatus ippiSet_<mod>(Ipp<datatype> value, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

| 8u_C3CR | 16u_C3CR | 16s_C3CR | 32s_C3CR | 32f_C3CR |
| 8u_C4CR | 16u_C4CR | 16s_C4CR | 32s_C4CR | 32f_C4CR |

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

value

Constant value to assign to each pixel in the destination image ROI.

pDst

Pointer to the destination image ROI.

dstStep

Distance, in bytes, between the starting points of consecutive lines in the destination image.

roiSize

Size of the image ROI in pixels.

pMask

Pointer to the mask image buffer.
**maskStep**

Distance, in bytes, between the starting points of consecutive lines in the mask image buffer.

**Description**

This function operates with ROI.

This function sets pixels in the destination image ROI $pDst$ to the value constant. Either all pixels in a rectangular ROI, or only those selected by the specified mask $pMask$, can be set to a value. In case of masked operation, the function sets pixel values in the destination buffer only if the spatially corresponding mask array value is non-zero. When a channel of interest is selected, that is only one channel of a multi-channel image must be set (see **Case 7**), the $pDst$ pointer points to the start of ROI buffer in the required channel. If alpha channel is present in the source image data, the alpha components may be either skipped, or set to a value, depending on the chosen ippiSet function flavor.

This function supports negative step value.

**Return Values**

- **ippiStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippiStsNullPtrErr**: Indicates an error when any of the specified pointers is NULL.
- **ippiStsSizeErr**: Indicates an error condition if roiSize has a field with zero or negative value.
- **ippiStsStepErr**: Indicates an error condition if dstStep or maskStep has a zero value.

**Example**

The code example below shows how to use the function ippiSet_8u_C1R.

```c
void func_set()
{
    IppiSize roi = {5,4};
    Ipp8u x[8*4] = {0};
    ippiSet_8u_C1R(1, x, 8, roi);
}
```

**Result:**

```
01 01 01 01 01 01 01 01
01 01 01 01 01 01 01 01
01 01 01 01 01 01 01 01
```

**See Also**

Regions of Interest in Intel IPP

**Copy**

*Copies pixel values between two buffers.*
Syntax

Case 1: Copying all pixels of all color channels

IppStatus ippiCopy_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

<table>
<thead>
<tr>
<th>8u_C1R</th>
<th>16u_C1R</th>
<th>16s_C1R</th>
<th>32s_C1R</th>
<th>32f_C1R</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_C3R</td>
<td>16u_C3R</td>
<td>16s_C3R</td>
<td>32s_C3R</td>
<td>32f_C3R</td>
</tr>
<tr>
<td>8u_C4R</td>
<td>16u_C4R</td>
<td>16s_C4R</td>
<td>32s_C4R</td>
<td>32f_C4R</td>
</tr>
<tr>
<td>8u_AC4R</td>
<td>16u_AC4R</td>
<td>16s_AC4R</td>
<td>32s_AC4R</td>
<td>32f_AC4R</td>
</tr>
<tr>
<td>8u_C3AC4</td>
<td>16u_C3AC4</td>
<td>16s_C3AC4</td>
<td>32s_C3AC4</td>
<td>32f_C3AC4</td>
</tr>
<tr>
<td>8u_AC4C3R</td>
<td>16u_AC4C3R</td>
<td>16s_AC4C3R</td>
<td>32s_AC4C3R</td>
<td>32f_AC4C3R</td>
</tr>
</tbody>
</table>

Case 2: Copying masked pixels only

IppStatus ippiCopy_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp8u* pMask, int maskStep);

Supported values for mod:

<table>
<thead>
<tr>
<th>8u_C1MR</th>
<th>16u_C1MR</th>
<th>16s_C1MR</th>
<th>32s_C1MR</th>
<th>32f_C1MR</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_C3MR</td>
<td>16u_C3MR</td>
<td>16s_C3MR</td>
<td>32s_C3MR</td>
<td>32f_C3MR</td>
</tr>
<tr>
<td>8u_C4MR</td>
<td>16u_C4MR</td>
<td>16s_C4MR</td>
<td>32s_C4MR</td>
<td>32f_C4MR</td>
</tr>
<tr>
<td>8u_AC4MR</td>
<td>16u_AC4MR</td>
<td>16s_AC4MR</td>
<td>32s_AC4MR</td>
<td>32f_AC4MR</td>
</tr>
</tbody>
</table>

Case 3: Copying a selected channel in a multi-channel image

IppStatus ippiCopy_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

<table>
<thead>
<tr>
<th>8u_C3CR</th>
<th>16u_C3CR</th>
<th>16s_C3CR</th>
<th>32s_C3CR</th>
<th>32f_C3CR</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_C4CR</td>
<td>16u_C4CR</td>
<td>16s_C4CR</td>
<td>32s_C4CR</td>
<td>32f_C4CR</td>
</tr>
</tbody>
</table>

Case 4: Copying a selected channel to a one-channel image

IppStatus ippiCopy_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

<table>
<thead>
<tr>
<th>8u_C3C1R</th>
<th>16u_C3C1R</th>
<th>16s_C3C1R</th>
<th>32s_C3C1R</th>
<th>32f_C3C1R</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_C4C1R</td>
<td>16u_C4C1R</td>
<td>16s_C4C1R</td>
<td>32s_C4C1R</td>
<td>32f_C4C1R</td>
</tr>
</tbody>
</table>

Case 5: Copying a one-channel image to a multi-channel image

IppStatus ippiCopy_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

<table>
<thead>
<tr>
<th>8u_C1C3R</th>
<th>16u_C1C3R</th>
<th>16s_C1C3R</th>
<th>32s_C1C3R</th>
<th>32f_C1C3R</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_C1C4R</td>
<td>16u_C1C4R</td>
<td>16s_C1C4R</td>
<td>32s_C1C4R</td>
<td>32f_C1C4R</td>
</tr>
</tbody>
</table>
**Case 6: Splitting color image into separate planes**

IppStatus ippiCopy_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* const pDst[3], int dstStep, IppiSize roiSize);

Supported values for mod:

8u_C3P3R  16u_C3P3R  16s_C3P3R  32s_C3P3R  32f_C3P3R

IppStatus ippiCopy_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* const pDst[4], int dstStep, IppiSize roiSize);

Supported values for mod:

8u_C4P4R  16u_C4P4R  16s_C4P4R  32s_C4P4R  32f_C4P4R

**Case 7: Composing color image from separate planes**

IppStatus ippiCopy_<mod>(const Ipp<datatype>* const pSrc[3], int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

8u_P3C3R  16u_P3C3R  16s_P3C3R  32s_P3C3R  32f_P3C3R

IppStatus ippiCopy_<mod>(const Ipp<datatype>* const pSrc[4], int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

8u_P4C4R  16u_P4C4R  16s_P4C4R  32s_P4C4R  32f_P4C4R

**Case 8: Copying all pixels of all color channels with platform-aware functions**

IppStatus ippiCopy_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize);

Supported values for mod:

8u_C1R_L  16s_C1R_L  16u_C1R_L  32s_C1R_L  32f_C1R_L
8u_C3R_L  16s_C3R_L  16u_C3R_L  32s_C3R_L  32f_C3R_L
8u_C4R_L  16s_C4R_L  16u_C4R_L  32s_C4R_L  32f_C4R_L
8u_AC4R_L  16s_AC4R_L  16u_AC4R_L  32s_AC4R_L  32f_AC4R_L

**Include Files**

ippi.h

Flavors with the \_L suffix: ippi\_L.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

pSrc
Pointer to the source image ROI. The array storing pointers to the color planes of the source planar image.

srcStep
Distance, in bytes, between the starting points of consecutive lines in the source image.

pDst
Pointer to the destination image ROI. The array storing pointers to the color planes of the destination planar image.

dstStep
Distance, in bytes, between the starting points of consecutive lines in the destination image.

roiSize
Size of the source and destination ROI in pixels.

pMask
Pointer to the mask image buffer.

maskStep
Distance, in bytes, between the starting points of consecutive lines in the mask image buffer.

Description

This function operates with ROI.

This function copies data from the source image pSrc to the destination image pDst. Copying pixels selected by a mask pMask is supported as well.

For masked operation (Case 2), the function writes pixel values in the destination buffer only if the spatially corresponding mask array value is non-zero (as illustrated in the code example below).

Function flavors operating with the channel of interest (descriptor C) copy only one specified channel of a source multi-channel image to the channel of another multi-channel image (see Case 3). For these functions, the pSrc and pDst pointers point to the starts of ROI buffers in the specified channels of source and destination images, respectively.

Some function flavors add alpha channel to the 3-channel source image (flavors with the _C3AC4R descriptor), or discard alpha channel from the source image (flavors with the _AC4C3R descriptor) - see Case 1.

Special function flavors copy data from only one specified channel pSrc of a multi-channel image to a one-channel image pDst (see Case 4), as well as to copy data from a one-channel image pSrc to only one specified channel of a multi-channel image pDst (see Case 5).

You can also use the ippiCopy function to convert the interleaved color image into separate planes and vice versa (see Case 6 and Case 7).

Return Values

ippiStsNoErr
Indicates no error. Any other value indicates an error or a warning.

ippiStsNullPtrErr
Indicates an error when any of the specified pointers is NULL, with the exception of second mode in Case 4.

ippiStsSizeErr
Indicates an error condition if roiSize has a field with a zero or negative value.

ippiStsStepErr
Indicates an error condition if srcStep or dstStep is less than roiSize.width * <pixelSize> for Cases 4 and 5.
Example

The code example below shows how to copy masked data.

```c
IppStatus copyWithMask( void ) {
    Ipp8u mask[3*3], x[5*4], y[5*4]={0};
    IppiSize imgroi={5,4}, mskroi={3,3};
   ippiSet_8u_C1R( 3, x, 5, imgroi );
    /// set mask with a hole in upper left corner
    ippiSet_8u_C1R( 1, mask, 3, mskroi );
    mask[0] = 0;
    /// copy roi with mask
    return ippiCopy_8u_C1MR( x, 5, y, 5, mskroi, mask, 3 );
}
```

The destination image \( y \) contains:

```
00 03 03 00 00 03 03 03 00 00 03 03 03 00 00 00 00 00 00 00
```

See Also

Regions of Interest in Intel IPP

CopyManaged

Copies pixel values between two images in accordance with the specified type of copying.

Syntax

```c
IppStatus ippiCopyManaged_8u_C1R( const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, int flags );
```

Include Files

`ippi.h`

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- `pSrc`  
  Pointer to the source image ROI.

- `srcStep`  
  Distance, in bytes, between the starting points of consecutive lines in the source image.

- `pDst`  
  Pointer to the destination image ROI.

- `dstStep`  
  Distance, in bytes, between the starting points of consecutive lines in the destination image.

- `roiSize`  
  Size of the image ROI in pixels.

- `flags`  
  Specifies the type of copying. Possible values are:
Description

This function operates with ROI.

This function copies data from a source image ROI \( pSrc \) to the destination image ROI \( pDst \). The \( flags \) parameter specifies the type of copying that the function performs:

- When \( flags \) is set to \( IPP_TEMPORAL_COPY \), the function is identical to the \( ippiCopy_8u_C1R \) function.
- When \( flags \) is set to \( IPP_NONTEMPORAL_STORE \), the processor uses non-temporal store instructions. Copying is performed without caching the data of the destination image.
- When \( flags \) is set to \( IPP_NONTEMPORAL_LOAD \), the processor uses non-temporal load instructions.

To achieve better performance, align data to 64-byte boundary.

Optimization Notice

Intel’s compilers may or may not optimize to the same degree for non-Intel microprocessors for optimizations that are not unique to Intel microprocessors. These optimizations include SSE2, SSE3, and SSSE3 instruction sets and other optimizations. Intel does not guarantee the availability, functionality, or effectiveness of any optimization on microprocessors not manufactured by Intel. Microprocessor-dependent optimizations in this product are intended for use with Intel microprocessors. Certain optimizations not specific to Intel microarchitecture are reserved for Intel microprocessors. Please refer to the applicable product User and Reference Guides for more information regarding the specific instruction sets covered by this notice.

Notice revision #20110804

Return Values

- \( ippStsNoErr \): Indicates no error. Any other value indicates an error or a warning.
- \( ippStsNullPtrErr \): Indicates an error when one of the specified pointers is \texttt{NULL}.
- \( ippStsSizeErr \): Indicates an error when \( roiSize \) has a field with a zero or negative value.

See Also

- Regions of Interest in Intel IPP

CopyConstBorder

Copies pixels values between two images and adds the border pixels with a constant value.
Syntax

Case 1: Not-in-place operation on one-channel data

IppStatus ippiCopyConstBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize srcRoiSize, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, int topBorderHeight, int leftBorderWidth, Ipp<datatype> value);

Supported values for mod:

8u_C1R 16u_C1R 16s_C1R 32s_C1R 32f_C1R

Case 2: In-place operation on one-channel data

IppStatus ippiCopyConstBorder_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize srcRoiSize, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, int topBorderHeight, int leftBorderWidth, const Ipp<datatype> value);

Supported values for mod:

8u_C1IR 16u_C1IR 16s_C1IR 32s_C1IR 32f_C1IR

Case 3: Not-in-place operation on multi-channel data

IppStatus ippiCopyConstBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize srcRoiSize, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, int topBorderHeight, int leftBorderWidth, const Ipp<datatype> value[3]);

Supported values for mod:

8u_C3R 16u_C3R 16s_C3R 32s_C3R 32f_C3R
8u_AC4R 16u_AC4R 16s_AC4R 32s_AC4R 32f_AC4R

IppStatus ippiCopyConstBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize srcRoiSize, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, int topBorderHeight, int leftBorderWidth, const Ipp<datatype> value[4]);

Supported values for mod:

8u_C4R 16u_C4R 16s_C4R 32s_C4R 32f_C4R

Case 4: In-place operation on multi-channel data

IppStatus ippiCopyConstBorder_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize srcRoiSize, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, int topBorderHeight, int leftBorderWidth, const Ipp<datatype> value[3]);

Supported values for mod:

8u_C3IR 16u_C3IR 16s_C3IR 32s_C3IR 32f_C3IR
8u_AC4IR 16u_AC4IR 16s_AC4IR 32s_AC4IR 32f_AC4IR

IppStatus ippiCopyConstBorder_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize srcRoiSize, Ipp<datatype> dstRoiSize, int topBorderHeight, int leftBorderWidth, const Ipp<datatype> value[4]);

Supported values for mod:

8u_C4IR 16u_C4IR 16s_C4IR 32s_C4IR 32f_C4IR
Case 5: Not-in-place operation on one-channel data with platform-aware functions


Supported values for mod:
8u_C1R_L 16u_C1R_L 16s_C1R_L 32s_C1R_L 32f_C1R_L

Case 6: In-place operation on one-channel data with platform-aware functions

IppStatus ippiCopyConstBorder_<mod>(Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppSizeL srcRoiSize, IppSizeL dstRoiSize, Ipp<datatype> value);

Supported values for mod:
8u_C1IR_L 16u_C1IR_L 16s_C1IR_L 32s_C1IR_L 32f_C1IR_L

Case 7: Not-in-place operation on multi-channel data with platform-aware functions


Supported values for mod:
8u_C3R_L 16u_C3R_L 16s_C3R_L 32s_C3R_L 32f_C3R_L
8u_AC4R_L 16u_AC4R_L 16s_AC4R_L 32s_AC4R_L 32f_AC4R_L


Supported values for mod:
8u_C4R_L 16u_C4R_L 16s_C4R_L 32s_C4R_L 32f_C4R_L

Case 8: In-place operation on multi-channel data with platform-aware functions


Supported values for mod:
8u_C3IR_L 16u_C3IR_L 16s_C3IR_L 32s_C3IR_L 32f_C3IR_L
8u_AC4IR_L 16u_AC4IR_L 16s_AC4IR_L 32s_AC4IR_L 32f_AC4IR_L


Supported values for mod:
8u_C4IR_L 16u_C4IR_L 16s_C4IR_L 32s_C4IR_L 32f_C4IR_L

Include Files
ippi.h
Flavors with the _L suffix: ippi_l.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the destination image.
- **pSrcDst**: Pointer to the source/destination image (for in-place flavors).
- **dstStep**: Distance, in bytes, between the starting points of consecutive lines in the destination image.
- **srcDstStep**: Distance, in bytes, between the starting points of consecutive lines in the source/destination image (for in-place flavors).
- **srcRoiSize**: Size of the source ROI, in pixels.
- **dstRoiSize**: Size of the destination ROI, in pixels.
- **topBorderHeight**: Height of the top border, in pixels.
- **leftBorderWidth**: Width of the left border, in pixels.
- **value**: The constant value to assign to the border pixels (constant vector in case of multi-channel images).

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).
This function copies the source image pSrc to the destination image pDst and creates border outside the copied area; pixel values of the border are set to the specified constant value that is passed by the value argument. The parameters topBorderHeight and leftBorderWidth specify the position of the first pixel of the source ROI in the destination image ROI (see Figure Creating a Border of Pixels with Constant Value.) Squares marked in red correspond to pixels copied from the source image, that is, the source image ROI.

**Creating a Border of Pixels with Constant Value**

<table>
<thead>
<tr>
<th>v</th>
<th>v</th>
<th>v</th>
<th>v</th>
<th>v</th>
<th>v</th>
<th>v</th>
<th>v</th>
</tr>
</thead>
<tbody>
<tr>
<td>v</td>
<td>v</td>
<td>v</td>
<td>v</td>
<td>v</td>
<td>v</td>
<td>v</td>
<td>v</td>
</tr>
<tr>
<td>v</td>
<td>v</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>v</td>
</tr>
<tr>
<td>v</td>
<td>v</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>v</td>
</tr>
<tr>
<td>v</td>
<td>v</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>v</td>
</tr>
<tr>
<td>v</td>
<td>v</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td>19</td>
<td>20</td>
<td>v</td>
</tr>
</tbody>
</table>
| v | v | v | v | v | v | v | v | topBorderHeight=2
leftBorderWidth=2

The height (width) of the destination ROI cannot be less than the sum of the height (width) of source ROI and the topBorderHeight (leftBorderWidth) parameter.

**Return Values**

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error when any of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error condition if srcRoiSize or dstRoiSize has a field with a zero or negative value, or topBorderHeight or leftBorderWidth is less than zero, or dstRoiSize.width < srcRoiSize.width + leftBorderWidth, or dstRoiSize.height < srcRoiSize.height + topBorderHeight.
- ippStsStepErr: Indicates an error condition if srcStep or dstStep has a zero or negative value.

**Example**

The code example below shows how to use the function ippiCopyConstBorder_8u_C1R.

```c
Ipp8u src[8*4] = {3, 3, 3, 3, 3, 8, 8, 8,
                   3, 2, 1, 2, 3, 8, 8, 8,
                   3, 2, 1, 2, 3, 8, 8, 8,
                   3, 3, 3, 3, 3, 8, 8, 8};
Ipp8u dst[8*6];
IppSize srcRoi = { 5, 4 };
```
IppSize dstRoi = { 7, 6 };
int borderWidth  = 1;
int borderHeight = 1;
int borderVal = 0;
ippiCopyConstBorder_8u_C1R(src, 8, srcRoi, dst, 8, dstRoi, borderHeight, borderWidth, borderVal);

Results
source image:
3 3 3 3 3 8 8 8
3 2 1 2 3 8 8 8
3 2 1 2 3 8 8 8  src
3 3 3 3 3 8 8 8

destination image:
0 0 0 0 0 0
0 3 3 3 3 3
0 3 2 1 2 3
0 3 2 1 2 3  dst
0 3 3 3 3 3
0 0 0 0 0 0

**CopyMirrorBorder**

Copies pixels values between two images and adds the mirrored border pixels.

**Syntax**

**Case 1: Not-in-place operation**

IppStatus ippiCopyMirrorBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize srcRoiSize, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, int topBorderHeight, int leftBorderWidth);

Supported values for mod:

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32s_C1R
- 32f_C1R
- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32s_C3R
- 32f_C3R
- 8u_C4R
- 16u_C4R
- 16s_C4R
- 32s_C4R
- 32f_C4R

**Case 2: In-place operation**

IppStatus ippiCopyMirrorBorder <mod>(const Ipp<datatype>* pSrc, int srcDstStep, IppiSize srcRoiSize, IppiSize dstRoiSize, int topBorderHeight, int leftBorderWidth);

Supported values for mod:

- 8u_C1IR
- 16u_C1IR
- 16s_C1IR
- 32s_C1IR
- 32f_C1IR
- 8u_C3IR
- 16u_C3IR
- 16s_C3IR
- 32s_C3IR
- 32f_C3IR
- 8u_C4IR
- 16u_C4IR
- 16s_C4IR
- 32s_C4IR
- 32f_C4IR
Case 3: Not-in-place operation with platform-aware functions

IppStatus ippiCopyMirrorBorder_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, IppSizeL srcRoiSize, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL dstRoiSize, IppSizeL topBorderHeight, IppSizeL leftBorderWidth);

Supported values for mod:

- 8u_C1R_L
- 16u_C1R_L
- 16s_C1R_L
- 32s_C1R_L
- 32f_C1R_L
- 8u_C3R_L
- 16u_C3R_L
- 16s_C3R_L
- 32s_C3R_L
- 32f_C3R_L
- 8u_C4R_L
- 16u_C4R_L
- 16s_C4R_L
- 32s_C4R_L
- 32f_C4R_L

Case 4: In-place operation with platform-aware functions

IppStatus ippiCopyMirrorBorder_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcDstStep, IppSizeL srcRoiSize, IppSizeL dstRoiSize, IppSizeL topBorderHeight, IppSizeL leftBorderWidth);

Supported values for mod:

- 8u_C1IR_L
- 16u_C1IR_L
- 16s_C1IR_L
- 32s_C1IR_L
- 32f_C1IR_L
- 8u_C3IR_L
- 16u_C3IR_L
- 16s_C3IR_L
- 32s_C3IR_L
- 32f_C3IR_L
- 8u_C4IR_L
- 16u_C4IR_L
- 16s_C4IR_L
- 32s_C4IR_L
- 32f_C4IR_L

Include Files

ippi.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- pSrc
- srcStep
- pDst
- dstStep
- srcDstStep
- srcRoiSize
- dstRoiSize
- topBorderHeight
- leftBorderWidth

- Pointer to the source image ROI.
- Distance, in bytes, between the starting points of consecutive lines in the source image.
- Pointer to the destination image.
- Distance, in bytes, between the starting points of consecutive lines in the destination image.
- Distance, in bytes, between the starting points of consecutive lines in the source and destination image.
- Size of the source ROI, in pixels.
- Size of the destination ROI, in pixels.
- Height of the top border, in pixels.
- Width of the left border, in pixels.
Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function copies the source image \( p_{Src} \) to the destination image \( p_{Dst} \) and fills pixels outside the copied area (border pixels) in the destination image with the values of the source image pixels according to the scheme illustrated in the figure below. Squares marked in red correspond to pixels copied from the source image, that is, the source image ROI.

Creating a Mirrored Border

\[
\begin{array}{cccccccc}
13 & 12 & 11 & 12 & 13 & 14 & 15 & 14 & 13 \\
8 & 7 & 6 & 7 & 8 & 9 & 10 & 9 & 8 \\
3 & 2 & 1 & 2 & 3 & 4 & 5 & 4 & 3 \\
8 & 7 & 6 & 7 & 8 & 9 & 10 & 9 & 8 \\
13 & 12 & 11 & 12 & 13 & 14 & 15 & 14 & 13 \\
18 & 17 & 16 & 17 & 18 & 19 & 20 & 19 & 18 \\
13 & 12 & 11 & 12 & 13 & 14 & 15 & 14 & 13 \\
\end{array}
\]

topBorderWidth=2
topBorderHeight=2

NOTE

In-place flavors actually add border pixels to the source image ROI, thus a destination image ROI is larger than the initial image.

The parameters topBorderHeight and leftBorderWidth specify the position of the first pixel of the source ROI in the destination image ROI.

The height (width) of the destination ROI cannot be less than the sum of the height (width) of source ROI and the topBorderHeight (leftBorderWidth) parameter.

NOTE

If border width is greater than the image size in the corresponding dimension, multiple reflections are obtained for this border.
NOTE
If you use this function for a tiled image, note that to perform correct mirroring, the size of a tile must be more than the size of the used border. For example, if the image referenced above is divided into two tiles of size 3x3 and 2x3, the second tile (cells are highlighted in yellow) is extended with top, right, and bottom borders (highlighted in gray). The width of the right border is not less than the second tile width, so the pixels (blue) required for constructing the border of the tiled image are out of the processed tile. Therefore the last column (red) of the border extended image is computed incorrectly:

<table>
<thead>
<tr>
<th>13</th>
<th>12</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>7</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>5</td>
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<tr>
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<td>19</td>
<td>20</td>
</tr>
<tr>
<td>13</td>
<td>12</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>14</td>
<td>15</td>
</tr>
</tbody>
</table>

Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr
Indicates an error when any of the specified pointers is NULL.

ippStsSizeErr
Indicates an error in any of the following cases:
- srcRoiSize or dstRoiSize has a field with a zero or negative value
- topBorderHeight or leftBorderWidth is less than zero
- dstRoiSize.width < srcRoiSize.width + leftBorderWidth
- dstRoiSize.height < srcRoiSize.height + topBorderHeight

ippStsStepErr
Indicates an error when srcStep or dstStep has a zero or negative value.

Example
The code example below shows how to use the ippiCopyMirrorBorder_8u_C1R function.

Ipp8u src[8*4] = { 1, 2, 3, 8, 8, 8, 8, 8,
10, 9, 8, 8, 8, 8, 8, 8,
11, 12, 13, 8, 8, 8, 8, 8,
19, 18, 17, 8, 8, 8, 8, 8};
Ipp8u dst[10*8];
IppiSize srcRoi = { 3, 4 }; IppiSize dstRoi = { 10, 8 };
int topBorderHeight = 2;
int leftBorderWidth = 2;
ippiCopyMirrorBorder_8u_C1R(src, 8, srcRoi, dst, 10, dstRoi, topBorderHeight, leftBorderWidth);

Result:

source image:
1  2  3  8  8  8  8  8
10 9  8  8  8  8  8  8
11 12 13  8  8  8  8  8
19 18 17  8  8  8  8  8

destination image:
13 12 11 12 13 12 11 12 13 12
8  9 10  9  8  9 10  9  8  9
3  2  1  2  3  2  1  2  3  2
8  9 10  9  8  9 10  9  8  9
13 12 11 12 13 12 11 12 13 12
17 18 19 18 17 18 19 18 17 18
13 12 11 12 13 12 11 12 13 12
8  9 10  9  8  9 10  9  8  9

See Also
Regions of Interest in Intel IPP

CopyReplicateBorder

Copies pixels values between two images and adds the replicated border pixels.

Syntax

Case 1: Not-in-place operation

IppStatus ippiCopyReplicateBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize srcRoiSize, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, int topBorderHeight, int leftBorderWidth);

Supported values for mod:

8u_C1R  16u_C1R  16s_C1R  32s_C1R  32f_C1R
8u_C3R  16u_C3R  16s_C3R  32s_C3R  32f_C3R
8u_C4R  16u_C4R  16s_C4R  32s_C4R  32f_C4R
8u_AC4R 16u_AC4R 16s_AC4R 32s_AC4R 32f_AC4R

Case 2: In-place operation

IppStatus ippiCopyReplicateBorder_<mod>(const Ipp<datatype>* pSrc, int srcDstStep, IppiSize srcRoiSize, IppiSize dstRoiSize, int topBorderHeight, int leftBorderWidth);

Supported values for mod:

8u_C1IR 16u_C1IR 16s_C1IR 32s_C1IR 32f_C1IR
8u_C3IR 16u_C3IR 16s_C3IR 32s_C3IR 32f_C3IR
8u_C4IR 16u_C4IR 16s_C4IR 32s_C4IR 32f_C4IR
8u_AC4IR  16u_AC4IR  16s_AC4IR  32s_AC4IR  32f_AC4IR

Case 3: Not-in-place operation for platform-aware functions

IppStatus ippiCopyReplicateBorder_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, IppiSizeL srcRoiSize, Ipp<datatype>* pDst, IppSizeL dstStep, IppiSizeL dstRoiSize, IppSizeL topBorderHeight, IppSizeL leftBorderWidth);

Supported values for mod:

8u_C1R_L  16u_C1R_L  16s_C1R_L  32s_C1R_L  32f_C1R_L
8u_C3R_L  16u_C3R_L  16s_C3R_L  32s_C3R_L  32f_C3R_L
8u_C4R_L  16u_C4R_L  16s_C4R_L  32s_C4R_L  32f_C4R_L
8u_AC4R_L  16u_AC4R_L  16s_AC4R_L  32s_AC4R_L  32f_AC4R_L

Case 4: In-place operation for platform-aware functions

IppStatus ippiCopyReplicateBorder_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcDstStep, IppiSizeL srcRoiSize, IppiSizeL dstRoiSize, IppSizeL topBorderHeight, IppSizeL leftBorderWidth);

Supported values for mod:

8u_C1IR_L  16u_C1IR_L  16s_C1IR_L  32s_C1IR_L  32f_C1IR_L
8u_C3IR_L  16u_C3IR_L  16s_C3IR_L  32s_C3IR_L  32f_C3IR_L
8u_C4IR_L  16u_C4IR_L  16s_C4IR_L  32s_C4IR_L  32f_C4IR_L
8u_AC4IR_L  16u_AC4IR_L  16s_AC4IR_L  32s_AC4IR_L  32f_AC4IR_L

Include Files

ippi.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc  
Pointer to the source image ROI.

srcStep  
Distance in bytes between starts of consecutive lines in the source image.

pDst  
Pointer to the destination image.

dstStep  
Distance in bytes between starts of consecutive lines in destination image.

srcDstStep  
Distance in bytes between starts of consecutive lines in the source and the destination image.

srcRoiSize  
Size of the source ROI in pixels.

dstRoiSize  
Size of the destination ROI in pixels.

topBorderHeight  
Height of the top border in pixels.
**leftBorderWidth**

Width of the left border in pixels.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function copies the source image \( p\text{Src} \) to the destination image \( p\text{Dst} \) and fills pixels ("border") outside the copied area in the destination image with the values of the source image pixels according to the scheme illustrated in Figure Creating a Replicated Border. Squares marked in red correspond to pixels copied from the source image, that is, the source image ROI.

Note that the in-place function flavor actually adds border pixels to the source image ROI, thus a destination image ROI is larger than the initial image.

The parameters \( \text{topBorderHeight} \) and \( \text{leftBorderWidth} \) specify the position of the first pixel of the source ROI in the destination image ROI.

**Creating a Replicated Border**

![Replicated Border Diagram]

The height (width) of the destination ROI cannot be less than the sum of the height (width) of source ROI and the \( \text{topBorderHeight} \) (\( \text{leftBorderWidth} \)) parameter.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when any of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if \( \text{srcRoiSize} \) or \( \text{dstRoiSize} \) has a field with a zero or negative value, or \( \text{topBorderHeight} \) or \( \text{leftBorderWidth} \) is less than zero, or \( \text{dstRoiSize.width} < \text{srcRoiSize.width} + \text{leftBorderWidth} \), or \( \text{dstRoiSize.height} < \text{srcRoiSize.height} + \text{topBorderHeight} \).
- **ippStsStepErr**: Indicates an error condition if \( \text{srcStep} \) or \( \text{dstStep} \) has a zero or negative value.
Example

The code example below shows how to use the `ippiCopyReplicateBorder_8u_C1R` function.

```c
Ipp8u src[8*4] = {5, 4, 3, 4, 5, 8, 8, 8,
                 3, 2, 1, 2, 3, 8, 8, 8,
                 3, 2, 1, 2, 3, 8, 8, 8,
                 5, 4, 3, 4, 5, 8, 8, 8};
Ipp8u dst[9*8];
IppiSize srcRoi = { 5, 4 };
IppiSize dstRoi = { 9, 8 };
int topborderHeight = 2;
int leftborderWidth = 2;
ippiCopyReplicateBorder_8u_C1R(src, 8, srcRoi, dst, 9, dstRoi, topBorderHeight, leftBorderWidth);
```

Results

source image:
5 4 3 4 5 8 8 8
3 2 1 2 3 8 8 8
3 2 1 2 3 8 8 8
5 4 3 4 5 8 8 8

destination image:
5 5 5 4 3 4 5 5 5
5 5 5 4 3 4 5 5 5
5 5 5 4 3 4 5 5 5
3 3 3 2 1 2 3 3 3
3 3 3 2 1 2 3 3 3
5 5 5 4 3 4 5 5 5
5 5 5 4 3 4 5 5 5
5 5 5 4 3 4 5 5 5

CopyWrapBorder

Copies pixels values between two images and adds the border pixels.

Syntax

Case 1: Not-in-place operation

```c
IppStatus ippiCopyWrapBorder_32s_C1R(const Ipp32s* pSrc, int srcStep, IppiSize srcRoiSize, Ipp32s* pDst, int dstStep, IppiSize dstRoiSize, int topBorderHeight, int leftBorderWidth);
IppStatus ippiCopyWrapBorder_32f_C1R(const Ipp32f* pSrc, int srcStep, IppiSize srcRoiSize, Ipp32f* pDst, int dstStep, IppiSize dstRoiSize, int topBorderHeight, int leftBorderWidth);
```

Case 2: In-place operation

```c
IppStatus ippiCopyWrapBorder_32s_C1IR(const Ipp32s* pSrc, int srcDstStep, IppiSize srcRoiSize, IppiSize dstRoiSize, int topBorderHeight, int leftBorderWidth);
IppStatus ippiCopyWrapBorder_32f_C1IR(const Ipp32f* pSrc, int srcDstStep, IppiSize srcRoiSize, IppiSize dstRoiSize, int topBorderHeight, int leftBorderWidth);
```
Case 3: Not-in-place operation with platform-aware functions

IppStatus ippiCopyWrapBorder_32s_C1R_L(const Ipp32s* pSrc, IppSizeL srcStep, IppSizeL srcRoiSize, Ipp32s* pDst, IppSizeL dstStep, IppSizeL dstRoiSize, IppSizeL topBorderHeight, IppSizeL leftBorderWidth);

IppStatus ippiCopyWrapBorder_32f_C1R_L(const Ipp32f* pSrc, IppSizeL srcStep, IppSizeL srcRoiSize, Ipp32f* pDst, IppSizeL dstStep, IppSizeL dstRoiSize, IppSizeL topBorderHeight, IppSizeL leftBorderWidth);

Case 4: In-place operation with platform-aware functions

IppStatus ippiCopyWrapBorder_32s_C1IR_L(const Ipp32s* pSrc, IppSizeL srcDstStep, IppSizeL srcRoiSize, IppSizeL dstRoiSize, IppSizeL topBorderHeight, IppSizeL leftBorderWidth);

IppStatus ippiCopyWrapBorder_32f_C1IR_L(const Ipp32f* pSrc, IppSizeL srcDstStep, IppSizeL srcRoiSize, IppSizeL dstRoiSize, IppSizeL topBorderHeight, IppSizeL leftBorderWidth);

Include Files

ippi.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc  
Pointer to the source image ROI.

srcStep  
Distance in bytes between starts of consecutive lines in the source image.

pDst  
Pointer to the destination image ROI.

dstStep  
Distance in bytes between starts of consecutive lines in the destination image.

srcDstStep  
Distance in bytes between starts of consecutive lines in the source and destination image for in-place flavor.

srcRoiSize  
Size of the source ROI in pixels.

dstRoiSize  
Size of the destination ROI in pixels.

topBorderHeight  
Height of the top border in pixels.

leftBorderWidth  
Width of the left border in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function copies the source image pSrc to the destination image pDst and fills pixels ("border") outside the copied area in the destination image with the values of the source image pixels according to the scheme illustrated in Figure Creating a Border of Pixels by ippiCopyWrapBorder Function. Squares marked in red correspond to pixels copied from the source image.
Note that the in-place function flavor actually adds border pixels to the source image ROI, thus a destination image ROI is larger than the initial image.

The parameters \texttt{topBorderHeight} and \texttt{leftBorderWidth} specify the position of the first pixel of the source ROI in the destination image ROI.

**Creating a Border of Pixels by \texttt{ippiCopyWrapBorder} Function**

![Image of array with border highlighted]

The height (width) of the destination ROI cannot be less than the sum of the height (width) of source ROI and the \texttt{topBorderHeight} (\texttt{leftBorderWidth}) parameter.

**Return Values**

- **\texttt{ippStsNoErr}** Indicates no error. Any other value indicates an error or a warning.
- **\texttt{ippStsNullPtrErr}** Indicates an error when any of the specified pointers is \texttt{NULL}.
- **\texttt{ippStsSizeErr}** Indicates an error condition if \texttt{srcRoiSize} or \texttt{dstRoiSize} has a field with a zero or negative value, or \texttt{topBorderHeight} or \texttt{leftBorderWidth} is less than zero, or \texttt{dstRoiSize.width} < \texttt{srcRoiSize.width + leftBorderWidth}, or \texttt{dstRoiSize.height} < \texttt{srcRoiSize.height + topBorderHeight}.
- **\texttt{ippStsStepErr}** Indicates an error condition if \texttt{srcStep} or \texttt{dstStep} has a zero or negative value.
- **\texttt{ippStsNotEvenStepErr}** Indicates an error condition if one of the step values is not divisible by 4 for floating point images, or by 2 for short integer images.

**Example**

The code example below shows how to use the \texttt{ippiCopyWrapBorder\_32s\_C1R} function.

```c
Ipp32s src[8*4] = {
    5, 4, 3, 4, 5, 8, 8, 8,
    3, 2, 1, 2, 3, 8, 8, 8,
    3, 2, 1, 2, 3, 8, 8, 8,
    5, 4, 3, 4, 5, 8, 8, 8
};
```
Ipp32s dst[9*8];
IppSize srcRoi = { 5, 4 };
IppSize dstRoi = { 9, 8 };
int topborderHeight = 2;
int leftborderWidth = 2;
ippiCopyWrapBorder_32s_C1R (src, 8*sizeof(Ipp32s), srcRoi, dst,
9*sizeof(Ipp32s), dstRoi, topBorderHeight, leftBorderWidth);

Results
source image:
5 4 3 4 5 8 8 8
3 2 1 2 3 8 8 8
3 2 1 2 3 8 8 8
5 4 3 4 5 8 8 8
destination image:
2 3 3 2 1 2 3 3 2
4 5 5 4 3 4 5 5 4
4 5 5 4 3 4 5 5 4
2 3 3 2 1 2 3 3 2
2 3 3 2 1 2 3 3 2
4 5 5 4 3 4 5 5 4
4 5 5 4 3 4 5 5 4
2 3 3 2 1 2 3 3 2

CopySubpix

Copies pixel values between two images with subpixel precision.

Syntax

Case 1: Copying without conversion or with conversion to floating point data
IppStatus ippiCopySubpix_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep,
Ipp<dstDatatype>* pDst, int dstStep, IppiSize roiSize, Ipp32f dx, Ipp32f dy);

Supported values for mod:
8u_C1R 16u_C1R 32f_C1R
8u32f_C1R 16u32f_C1R

Case 2: Copying with conversion to integer data
IppStatus ippiCopySubpix_8u16u_C1R_Sfs(const Ipp8u* pSrc, int srcStep, Ipp16u* pDst, int dstStep, IppiSize roiSize, Ipp32f dx, Ipp32f dy, int scaleFactor);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Parameters

\textbf{pSrc}  
Pointer to the source image ROI.

\textbf{srcStep}  
Distance in bytes between starts of consecutive lines in the source image.

\textbf{pDst}  
Pointer to the destination image ROI.

\textbf{dstStep}  
Distance in bytes between starts of consecutive lines in the destination image.

\textbf{roiSize}  
Size of the source and destination ROI in pixels.

\textbf{dx}  
Fractional part of the \(x\)-coordinate in the source image.

\textbf{dy}  
Fractional part of the \(y\)-coordinate in the source image.

\textbf{scaleFactor}  
Scale factor (see Integer Result Scaling).

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function computes the pixel value of the destination image using linear interpolation (see Linear Interpolation in Appendix B) in accordance with the following formula:

\[
p_{DST_{ij}} = p_{SRC_{i+dx,j+dy}}
\]

where \(i = 0, \ldots, \text{roiSize.height} - 1\), \(j = 0, \ldots, \text{roiSize.width} - 1\).

Return Values

\textbf{ippStsNoErr}  
Indicates no error. Any other value indicates an error or a warning.

\textbf{ippStsNullPtrErr}  
Indicates an error when any of the specified pointers is NULL.

\textbf{ippStsSizeErr}  
Indicates an error condition if \text{roiSize} has a field with a zero or negative value.

\textbf{ippStsStepErr}  
Indicates an error condition if \text{srcStep} or \text{dstStep} is less than \text{roiSize.width} * \text{<pixelSize>},

\textbf{ippStsNotEvenStepErr}  
Indicates an error condition if one of \text{srcStep} or \text{dstStep} is not divisible by 4 for floating point images, or by 2 for short integer images.

\textbf{CopySubpixIntersect}  
Copies pixel values of the intersection with specified window with subpixel precision.
**Syntax**

**Case 1: Copying without conversion or with conversion to floating point data**

IppStatus ippiCopySubpixIntersect_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, IppiSize srcRoiSize, Ipp<dstDatatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiPoint_32f point, IppiPoint* pMin, IppiPoint* pMax);

Supported values for mod:

- 8u_C1R
- 16u_C1R
- 32f_C1R
- 8u32f_C1R
- 16u32f_C1R

**Case 2: Copying with conversion to integer data**

IppStatus ippiCopySubpixIntersect_8u16u_C1R_Sfs(const Ipp8u* pSrc, int srcStep, IppiSize srcRoiSize, Ipp16u* pDst, int dstStep, IppiSize dstRoiSize, IppiPoint_32f point, IppiPoint* pMin, IppiPoint* pMax, int scaleFactor);

**Include Files**

ippcv.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **srcRoiSize**: Size of the source image ROI in pixels.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the source and destination image.
- **dstRoiSize**: Size of the destination ROI in pixels.
- **point**: Center point of the window.
- **pMin**: Pointer to coordinates of the top left pixel of the intersection in the destination image.
- **pMax**: Pointer to coordinates of the bottom right pixel of the intersection in the destination image.
- **scaleFactor**: Scale factor (see Integer Result Scaling).

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function determines the intersection of the source image and the window of size dstRoiSize centered in point point. The corresponding pixels of the destination image are calculated using linear interpolation (see Linear Interpolation in Appendix B) in accordance with the following formula:
where \( X_{\text{subpix}}(j) = \min(\max(point.x + j - 0.5*(\text{dstRoiSize.width} - 1), 0), \text{srcRoiSize.width} - 1) \),
\[ Y_{\text{subpix}}(i) = \min(\max(point.y + i - 0.5*(\text{dstRoiSize.height} - 1), 0), \text{srcRoiSize.height} - 1) \]
\[ i = 0, \ldots \text{dstRoiSize.height} - 1, j = 0, \ldots \text{dstRoiSize.width} - 1. \]

Minimal values of \( j \) and \( i \) (coordinates of the top left calculated destination pixel) are assigned to \( p_{\text{Min.x}} \) and \( p_{\text{Min.y}} \), maximal values (coordinates of the top left calculated destination pixel) - to \( p_{\text{Min.x}} \) and \( p_{\text{Min.y}} \). (See Figure Image Copying with Subpixel Precision Using ippiCopySubpixIntersect Function.)

**Image Copying with Subpixel Precision Using ippiCopySubpixIntersect Function**

The height (width) of the destination ROI cannot be less than the sum of the height (width) of source ROI and the \( \text{topBorderHeight} \) \( \text{(leftBorderWidth)} \) parameter.

**Return Values**

ippStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  
Indicates an error when any of the specified pointers is NULL.

ippStsSizeErr  
Indicates an error condition if \( \text{srcRoiSize} \) or \( \text{dstRoiSize} \) has a field with a zero or negative value.

ippStsStepErr  
Indicates an error condition if \( \text{srcStep} \) is less than \( \text{srcRoiSize.width} \times \text{<pixelSize>} \), or \( \text{dstStep} \) is less than \( \text{dstRoiSize.width} \times \text{<pixelSize>} \).

**Example**

The code example below shows how to use the function ippiCopySubpixIntersect_8u_C1R.

```c
Ipp8u src[8*6] = {
    7, 7, 6, 6, 6, 6, 7, 7,
    6, 5, 5, 5, 5, 5, 6,
};
```
Ipp8u dst[7*4];
IppiSize srcRoi = { 8, 6 };  
IppiSize dstRoi = { 7, 4 }; 
IppiPoint_32f point = { 4, 1 }; 
IppiPoint min; 
IppiPoint max;

ippiCopySubpixIntersect_8u_C1R (src, 8, srcRoi, dst, 7, dstRoi, point, &min, &max );

Results
source image:
7 7 6 6 6 7 7
6 5 5 5 5 5 6
6 5 4 3 3 4 5 6
6 5 4 3 3 4 5 6
6 5 5 5 5 5 6
6 6 6 6 6 6 6

destination image:
7 6 6 6 6 7 7
6 6 6 6 6 6 7
5 5 4 4 5 5 6
5 4 3 3 4 5 6
min = { 0, 1 }
max = { 5, 3 }

Dup
Copies a gray scale image to all channels of the color image.

Syntax
IppStatus ippiDup_8u_C1C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep,
IppiSize roiSize);
IppStatus ippiDup_8u_C1C4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep,
IppiSize roiSize);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
**Parameters**

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**: Size of the source and destination ROI in pixels.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function copies a one-channel (gray scale) image `pSrc` to each channel of the multi-channel image `pDst`.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when any of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if `RoiSize` has a field with a zero or negative value.

**Transpose**

*Transposes a source image.*

**Syntax**

**Case 1: Not-in-place operation**

IppStatus ippiTranspose_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for `mod`:

<table>
<thead>
<tr>
<th>8u_C1R</th>
<th>16u_C1R</th>
<th>16s_C1R</th>
<th>32s_C1R</th>
<th>32f_C1R</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_C3R</td>
<td>16u_C3R</td>
<td>16s_C3R</td>
<td>32s_C3R</td>
<td>32f_C3R</td>
</tr>
<tr>
<td>8u_C4R</td>
<td>16u_C4R</td>
<td>16s_C4R</td>
<td>32s_C4R</td>
<td>32f_C4R</td>
</tr>
</tbody>
</table>

**Case 2: In-place operation**

IppStatus ippiTranspose_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for `mod`:

<table>
<thead>
<tr>
<th>8u_C1IR</th>
<th>16u_C1IR</th>
<th>16s_C1IR</th>
<th>32s_C1IR</th>
<th>32f_C1IR</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_C3IR</td>
<td>16u_C3IR</td>
<td>16s_C3IR</td>
<td>32s_C3IR</td>
<td>32f_C3IR</td>
</tr>
<tr>
<td>8u_C4IR</td>
<td>16u_C4IR</td>
<td>16s_C4IR</td>
<td>32s_C4IR</td>
<td>32f_C4IR</td>
</tr>
</tbody>
</table>
Include Files
ippi.h

Domain Dependencies
Headers: ippicore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc  
Pointer to the source image ROI.

srcStep  
Distance, in bytes, between the starting points of consecutive lines in the source image.

pDst  
Pointer to the destination image ROI.

dstStep  
Distance, in bytes, between the starting points of consecutive lines in the destination image.

pSrcDst  
Pointer to the source and destination ROI for in-place operation.

srcDstStep  
Distance, in bytes, between the starting points of consecutive lines in the source and destination image buffer for the in-place operation.

roiSize  
Size of the source ROI in pixels.

Description
This function operates with ROI.
This function transposes the source image pSrc (pSrcDst for in-place flavors) and stores the result in pDst (pSrcDst). The destination image is obtained from the source image by transforming the columns to the rows: pDst(x,y) = pSrc(y,x)
The parameter roiSize is specified for the source image. The value of the roiSize.width parameter for the destination image is equal to roiSize.height for the source image, and roiSize.height for the destination image is equal to roiSize.width for the source image.

NOTE
For in-place operations, roiSize.width must be equal to roiSize.height.

Return Values

ippStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  
Indicates an error when any of the specified pointers is NULL, with the exception of second mode in Case 4.

ippStsSizeErr  
Indicates an error when:
- roiSize has a field with a zero or negative value
- roiSize.width is not equal to roiSize.height for in-place flavors
Example

The code example below shows how to use the ippiTranspose_8u_C1R function.

```c
Ipp8u src[8*4] = {1, 2, 3, 4, 8, 8, 8, 8,
                    1, 2, 3, 4, 8, 8, 8, 8,
                    1, 2, 3, 4, 8, 8, 8, 8,
                    1, 2, 3, 4, 8, 8, 8, 8};
Ipp8u dst[4*4];
IppiSize srcRoi = { 4, 4 };
ippiTranspose_8u_C1R ( src, 8, dst, 4, srcRoi );
```

Result:

```
1 2 3 4 8 8 8 8
1 2 3 4 8 8 8 8    src
1 2 3 4 8 8 8 8
1 1 1 1
dst
2 2 2 2
3 3 3 3
4 4 4 4
```

See Also

Regions of Interest in Intel IPP

SwapChannels

Copies channels of the source image to the destination image.

Syntax

**Case 1: Not-in-place operation**

```c
IppStatus ippiSwapChannels_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const int dstOrder[3]);
```

Supported values for `<mod>`:

- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32s_C3R
- 32f_C3R
- 8u_AC4R
- 16u_AC4R
- 16s_AC4R
- 32s_AC4R
- 32f_AC4R

**Case 2: In-place operation**

```c
IppStatus ippiSwapChannels_8u_C3IR(Ipp8u* pSrcDst, int srcDstStep, IppiSize roiSize, const int dstOrder[3]);
```
IppStatus ippiSwapChannels_8u_C4IR(Ipp8u* pSrcDst, int srcDstStep, IppiSize roiSize,
const int dstOrder[4]);

**Case 3: Operation with converting 3-channel image to the 4-channel image**

IppStatus ippiSwapChannels_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst,
int dstStep, IppiSize roiSize, const int dstOrder[4], Ipp<datatype> val);

Supported values for `mod`:

8u_C3C4R    16u_C3C4R    16s_C3C4R    32s_C3C4R    32f_C3C4R

**Case 4: Operation with converting 4-channel image to the 3-channel image**

IppStatus ippiSwapChannels_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst,
int dstStep, IppiSize roiSize, const int dstOrder[3]);

Supported values for `mod`:

8u_C4C3R    16u_C4C3R    16s_C4C3R    32s_C4C3R    32f_C4C3R

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **pSrc**
  Pointer to the source image ROI.

- **srcStep**
  Distance in bytes between starts of consecutive lines in the source image.

- **pDst**
  Pointer to the destination image ROI.

- **dstStep**
  Distance in bytes between starts of consecutive lines in the destination image.

- **pSrcDst**
  Pointer to the source and destination ROI for in-place operation.

- **srcDstStep**
  Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.

- **roiSize**
  Size of the source and destination ROI in pixels.

- **dstOrder**
  Order of channels in the destination image.

- **val**
  Constant value.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function copies the data from specified channels of the source image ROI `pSrc` to the specified channels of the destination image ROI `pDst`. 
The first channel in the destination image is determined by the first component of \( \text{dstOrder} \). Its value lies in the range \([0..2]\) for a 3-channel image, and \([0..3]\) for a 4-channel image, and indicates the corresponding channel number of the source image. Other channels are specified in the similar way. For example, if the sequence of channels in the source 3-channel image is \( A, B, C \), and \( \text{dstOrder}[0]=2, \text{dstOrder}[1]=0, \text{dstOrder}[2]=1 \), then the order of channels in the 3-channel destination image is \( C, A, B \). Some or all components of \( \text{dstOrder} \) may have the same values. It means that data from a certain channel of the source image may be copied to several channels of the destination image.

Some functions flavors convert a 3-channel source image to the 4-channel destination image (see Case 3). In this case an additional channel contains data from any specified source channel, or its pixel values are set to the specified constant value \( \text{val} \) (corresponding component \( \text{dstOrder}[n] \) should be set to 3), or its pixel values are not set at all (corresponding component \( \text{dstOrder}[n] \) should be set to an arbitrary value greater than 3). For example, if the sequence of channels in the source 3-channel image is \( A, B, C \), if \( \text{dstOrder}[0]=1, \text{dstOrder}[1]=0, \text{dstOrder}[2]=1, \text{dstOrder}[3]=2 \), then the order of channels in the 4-channel destination image will be \( B, A, B, C \); if \( \text{dstOrder}[0]=4, \text{dstOrder}[1]=0, \text{dstOrder}[2]=1, \text{dstOrder}[3]=2 \), then the order of channels in the 4-channel destination image will be \( D, A, B, C \), where \( D \) is a channel whose pixel values are not set.

The function flavors that support image with the alpha channel do not perform operation on it.

This function supports negative step values.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when any of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if \( \text{roiSize} \) has a field with zero or negative value.
- **ippStsStepErr**: Indicates an error condition if \( \text{srcStep} \) or \( \text{dstStep} \) has a zero value.

**Example**

The code example below shows how to use the function \( \text{ippiSwapChannels}_8u\_C3R \).

```c
Ipp8u src[12*3] = { 255, 0, 0, 255, 0, 0, 255, 0, 0, 255, 0, 0,
    0, 255, 0, 0, 255, 0, 0, 255, 0, 0, 255, 0,
    0, 0, 255, 0, 0, 255, 0, 0, 255, 0, 0, 255};
Ipp8u dst[12*3];
IppiSize roiSize = { 4, 3 }; int order[3] = { 2, 1, 0 }
ippiSwapChannels_8u_C3R ( src, 12, dst, 12, roiSize, order );
```

**Result:**

```
src    [rgb]
255 0 0 255 0 0 255 0 0 255 0 0
0 255 0 0 255 0 0 255 0 0 255 0
0 0 255 0 0 255 0 0 255 0 0 255

dst    [bgr]
0 0 255 0 0 255 0 0 255 0 0 255
```

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AddRandUniform

Generates random samples with uniform distribution and adds them to an image data.

Syntax

IppStatus ippiAddRandUniform_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp<datatype> low, Ipp<datatype> high, unsigned int* pSeed);

Supported values for mod:

- 8u_C1IR
- 16u_C1IR
- 16s_C1IR
- 32f_C1IR
- 8u_C3IR
- 16u_C3IR
- 16s_C3IR
- 32f_C3IR
- 8u_C4IR
- 16u_C4IR
- 16s_C4IR
- 32f_C4IR
- 8u_AC4IR
- 16u_AC4IR
- 16s_AC4IR
- 32f_AC4IR

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- pSrcDst: Pointer to the source and destination image ROI.
- srcDstStep: Distance in bytes between starts of consecutive lines in the source and destination image.
- roiSize: Size of the image ROI in pixels.
- low: The lower bound for the range of uniformly distributed values.
- high: The upper bound for the range of uniformly distributed values.
- pSeed: The initial seed value for the pseudo-random number generator.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

The function generates samples with uniform distribution over the range \([low, high]\) and adds them to a source image pointed to by pSrcDst.

The resulting pixel values that exceed the image data range are saturated to the respective data-range limits. To obtain an image that contains pure noise with uniform distribution, call ippiAddRandUniform using a source image with zero data as input.
Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when any of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if `roiSize` has a field with zero or negative value.
- **ippStsStepErr**: Indicates an error condition if `srcDstStep` has a zero or negative value.

Example

The code example below shows data conversion without scaling.

```c
IppStatus randUniform( void ) {
    unsigned int seed = 123456;
    Ipp8u img[2048], mn, mx;
    IppiSize roi={2048,1};
    Ipp64f mean;
    IppStatus st;
    ippiSet_8u_C1R( 0, img, 2048, roi );
    st = ippiAddRandUniform_8u_C1IR(img, 2048, roi, 0, 255, &seed);
    ippiMean_8u_C1R( img, 2048, roi, &mean );
    ippiMinMax_8u_C1R( img, 2048, roi, &mn, &mx );
    printf( "[%d..%d], mean=%.3f\n", mn, mx, mean );
    return st;
}
```

AddRandGauss

Generates random samples with Gaussian distribution and adds them to an image data.

Syntax

```
IppStatus ippiAddRandGauss_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp<datatype> mean, Ipp<datatype> stDev, unsigned int* pSeed);
```

Supported values for `mod`:

- 8u_C1IR
- 8u_C3IR
- 8u_C4IR
- 8u_AC4IR
- 16u_C1IR
- 16u_C3IR
- 16u_C4IR
- 16u_AC4IR
- 16s_C1IR
- 16s_C3IR
- 16s_C4IR
- 16s_AC4IR
- 32f_C1IR
- 32f_C3IR
- 32f_C4IR
- 32f_AC4IR

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

- `pSrcDst`: Pointer to the source and destination image ROI.
- `srcDstStep`: Distance in bytes between starts of consecutive lines in the source and destination image.
- `roiSize`: Size of the image ROI in pixels.
- `mean`: The mean of the Gaussian distribution.
- `stDev`: The standard deviation of the Gaussian distribution.
- `pSeed`: The initial seed value for the pseudo-random number generator.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

The function generates samples with Gaussian distribution that have the mean value `mean` and standard deviation `stDev` and adds them to a source image ROI pointed to by `pSrcDst`.

The resulting pixel values that exceed the image data range are saturated to the respective data-range limits. To obtain an image which contains pure noise with Gaussian distribution, call `ippiAddRandGauss` using a source image with zero data as input.

Return Values

- `ippStsNoErr`: Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr`: Indicates an error condition if `pSrcDst` or `pSeed` pointer is NULL.
- `ippStsSizeErr`: Indicates an error condition if `roiSize` has a field with zero or negative value.
- `ippStsStepErr`: Indicates an error condition if `srcDstStep` has a zero or negative value.

ImageJaehne

Creates Jaehne test image.

Syntax

```c
IppStatusippiImageJaehne_<mod>(Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);
```

Supported values for `mod`:

- `8u_C1R`, `16u_C1R`, `16s_C1R`, `32f_C1R`
- `8u_C3R`, `16u_C3R`, `16s_C3R`, `32f_C3R`
- `8u_C4R`, `16u_C4R`, `16s_C4R`, `32f_C4R`
- `8u_AC4R`, `16u_AC4R`, `16s_AC4R`, `32f_AC4R`

Include Files

`ippi.h`
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pDst**
  Pointer to the destination image ROI.

- **dstStep**
  Distance in bytes between starts of consecutive lines in the destination image.

- **roiSize**
  Size of the destination image ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function creates a specific one- or three-channel test image that has been first introduced to digital image processing by B.Jaehne (see [Jae95]).

The destination image pixel values are computed according to the following formula:

$$ Dst(x,y) = A \cdot \sin\left(0.5 \cdot IPP_PI \cdot \frac{x^2 + y^2}{\text{roiSize.height}}\right), $$

where $x, y$ are pixel coordinates varying in the range $0 \leq x \leq \text{roiSize.width}-1, 0 \leq y \leq \text{roiSize.height}-1$;

IPP_PI is the library constant that stands for $\pi$ value.

$$ x2 = \frac{(x - \text{roiSize.width}+1)/2.0,}$$

$$ y2 = \frac{(y - \text{roiSize.height}+1)/2.0,}$$

$A$ is the constant value that depends upon the image type being created.

For the $32f$ floating point data, the pixel values in the created image can vary in the range between 0 (inclusive) and 1 (exclusive).
Figure Example of a Generated Jaehne's Test Image illustrates an example of a test image generated by the ippiImageJaehne function.

**Example of a Generated Jaehne's Test Image**

These test images can be effectively used when you need to visualize and interpret the results of applying filtering functions, similarly to what is proposed in [Jae95].

### Return Values

- **ippStsNoErr**
  
  Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**
  
  Indicates an error condition if the `pDst` pointer is NULL.

- **ippStsSizeErr**
  
  Indicates an error condition if `roiSize` has a field with a zero or negative value, or if `dstStep` is less than or equal to zero.

### ImageRamp

**C**reates a test image that has an intensity ramp.

**Syntax**

```c
IppStatus ippiImageRamp_<mod>(Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, float offset, float slope, IppiAxis axis);
```

**Supported values for mod:**

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R
- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 8u_C4R
- 16u_C4R
- 16s_C4R
- 32f_C4R
Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**: Size of the destination image ROI in pixels.
- **offset**: Offset value.
- **slope**: Slope coefficient.
- **axis**: Specifies the direction of the image intensity ramp; can be one of the following:
  - ippAxsHorizontal for the ramp in X-direction,
  - ippAxsVertical for the ramp in Y-direction,
  - ippAxsBoth for the ramp in both X and Y-directions.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
The function creates a one- or three-channel image that can be used as a test image to examine the effect of applying different image processing functions.

The destination image pixel values are computed according to one of the following formulas:

\[
dst(x, y) = \text{offset} + \text{slope} \times x, \text{ if } \text{axis} = \text{ippAxsHorizontal}, \\
dst(x, y) = \text{offset} + \text{slope} \times y, \text{ if } \text{axis} = \text{ippAxsVertical}, \\
dst(x, y) = \text{offset} + \text{slope} \times x \times y, \text{ if } \text{axis} = \text{ippAxsBoth},
\]

where \(x, y\) are pixel coordinates varying in the range

\(0 \leq x \leq \text{roiSize.width}-1, 0 \leq y \leq \text{roiSize.height}-1;\)

Note that linear transform coefficients \(\text{offset}\) and \(\text{slope}\) have floating-point values for all function flavors.
The computed pixel values that exceed the image data range are saturated to the respective data-range limits.

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if the \(p\text{Dst}\) pointer is NULL.
Indicates an error condition if \textit{roiSize} has a field with a zero or negative value, or if \textit{dstStep} is less than or equal to zero.

\section*{Example}

The code example below illustrates how to use the \texttt{ippiImageRamp} function.

\begin{verbatim}
IppStatus ramp( void ){
    Ipp8u dst[8*4];
    IppiSize roiSize = { 8, 4 };
    return ippiImageRamp_8u_C1R( dst, 8, roiSize, 0.0f, 256.0f/7, ippAxsHorizontal);
}
\end{verbatim}

The destination image contains the following data:

\begin{verbatim}
    00 25 49 6E 92 B7 DB FF
    00 25 49 6E 92 B7 DB FF
    00 25 49 6E 92 B7 DB FF
    00 25 49 6E 92 B7 DB FF
\end{verbatim}

\section*{SampleLine}

\textit{Puts a raster line into buffer.}

\section*{Syntax}

\begin{verbatim}
IppStatus ippiSampleLine_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, Ipp<datatype>* pDst, IppiPoint pt1, IppiPoint pt2);
\end{verbatim}

\textbf{Supported values for} \texttt{mod}:

\begin{align*}
8u\_C1R & \quad 16u\_C1R & \quad 32f\_C1R \\
8u\_C3R & \quad 16u\_C3R & \quad 32f\_C3R
\end{align*}

\section*{Include Files}

ippcv.h

\section*{Domain Dependencies}

\textbf{Headers:} ippcore.h, ippvm.h, ipps.h,ippi.h

\textbf{Libraries:} ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

\section*{Parameters}

\begin{itemize}
    \item \textit{pSrc} \hspace{3cm} Pointer to the ROI in the source raster image.
    \item \textit{srcStep} \hspace{3cm} Distance in bytes between starts of consecutive lines in the raster image.
    \item \textit{roiSize} \hspace{3cm} Size of the image ROI in pixels.
    \item \textit{pDst} \hspace{3cm} Pointer to the destination buffer. The buffer is to store at least $\max(|pt2.x - pt1.x| + 1, |pt2.y - pt1.y| + 1)$ points.
    \item \textit{pt1} \hspace{3cm} Starting point of the line.
\end{itemize}
Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function iterates through the points that belong to the raster line using the 8-point connected
Bresenham algorithm, and puts the resulting pixels into the destination buffer.

Return Values
ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error condition if any of the specified pointers is NULL.
ippStsSizeErr Indicates an error condition if roiSize.width or roiSize.height is
less than or equal to zero.
ippStsStepErr Indicates an error condition if srcStep is less than roiSize.width *
<pixelSize>.
ippStsNotEvenStepErr Indicates an error when the step for the floating-point image cannot
be divided by 4.
ippStsOutOfRangeErr Indicates an error when any of the line ending points is outside the
image.

Example
The code example below shows how to use the function ippiSampleLine_8u_C1R .

```c
void func_sampleline()
{
    Ipp8u pSrc[5*4] = { 0, 1, 2, 3, 4,
                        5, 6, 7, 8, 9,
                        0, 9, 8, 7, 6,
                        5, 4, 3, 2, 1};
    IppiSize roiSize = {5, 4};
    IppiPoint pt1 = {1, 1};
    IppiPoint pt2 = {2, 3};
    Ipp8u pDst[3];
    int srcStep = 5;

    ippiSampleLine_8u_C1R( pSrc, srcStep, roiSize, pDst, pt1, pt2 );

    printf("%Result: d, %d, %d\n", pDst[0], pDst[1], pDst[2] ); // << this wrong line
    printf("%Result: %d, %d, %d\n", pDst[0], pDst[1], pDst[2] ); // this is correct line
}
```

Result: 6, 9, 3

ZigzagFwd8x8
Converting a conventional order to the zigzag order.

Syntax
IppStatus ippiZigzagFwd8x8_16s_C1(const Ipp16s* pSrc, Ipp16s* pDst);
Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc  
Pointer to the source data.

pDst  
Pointer to the destination data.

Description
This function rearranges data in an 8x8 block from a conventional order (left-to-right, top-to-bottom) to the zigzag sequence. Figure Zigzag Sequence specifies the resulting zigzag sequence.

Zigzag Sequence

\[
\begin{array}{cccccccc}
0 & 1 & 5 & 6 & 14 & 15 & 27 & 28 \\
2 & 4 & 7 & 13 & 16 & 26 & 29 & 42 \\
3 & 8 & 12 & 17 & 25 & 30 & 41 & 43 \\
9 & 11 & 18 & 24 & 31 & 40 & 44 & 53 \\
10 & 19 & 23 & 32 & 39 & 45 & 52 & 54 \\
20 & 22 & 33 & 46 & 51 & 55 & 56 & 60 \\
21 & 34 & 37 & 47 & 50 & 56 & 59 & 61 \\
35 & 36 & 48 & 49 & 57 & 58 & 62 & 63 \\
\end{array}
\]

Return Values

ippStsNoErr  
Indicates no error.

ippStsNullPtrErr  
Indicates an error when any of the specified pointers is NULL.

Example
The code example below shows how to use the ippiZigzagFwd8x8_16s_C1 function.

```c
Ipp16s src[8*8] = {
    0, 1, 5, 7, 9, 2, 4, 1,
    5, 4, 8, 6, 3, 8, 0, 3,
    6, 2, 6, 8, 1, 4, 2, 8,
    4, 3, 2, 9, 3, 0, 6, 6,
    7, 7, 3, 0, 4, 1, 0, 9,
    5, 1, 9, 2, 5, 7, 1, 7,
    0, 3, 5, 0, 7, 5, 9, 8,
    2, 9, 1, 4, 6, 8, 2, 3
};
Ipp16s dst[8*8];
```
ippiZigzagFwd8x8_16s_C1 ( src, dst );

Result:
0 1 5 7 9 2 4 1
5 4 8 6 3 8 0 3
6 2 6 8 1 4 2 8
4 3 2 9 3 0 6 6 //conventional order
7 7 3 0 4 1 0 9
5 1 9 2 5 7 1 7
0 3 5 0 7 5 9 8
2 9 1 4 6 8 2 3

0 1 5 6 4 5 7 8
2 4 7 3 6 6 9 2
3 8 2 7 5 0 1 3
9 1 8 4 1 0 4 3 //zigzag order
dst
0 9 3 2 9 5 2 4
0 2 3 8 6 1 5 0
1 4 7 7 0 6 9 1
5 6 8 9 7 8 2 3

ZigzagInv8x8

Converts a zigzag order to the conventional order.

Syntax
IppStatus ippiZigzagInv8x8_16s_C1(const Ipp16s* pSrc, Ipp16s* pDst);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc Pointer to the source data.
pDst Pointer to the destination data.

Description
This function rearranges data in an 8x8 block from a zigzag sequence to the conventional order (left-to-right, top-to-bottom).

Figure Zigzag Sequence specifies the resulting zigzag sequence.

Return Values

ippStsNoErr Indicates no error.
**ippStsNullPtrErr**

Indicates an error when any of the specified pointers is **NULL**.
This chapter describes functions that modify pixel values of an image buffer using arithmetic or logical operations. It also includes functions that perform image compositing based on opacity (alpha-blending).

An additional suffix \texttt{C}, if present in the function name, indicates operation with a constant. Arithmetic functions that operate on integer data perform fixed scaling of the internally computed results. In case of overflow the result value is saturated to the destination data type range.

\textbf{NOTE}
Most arithmetic and logical functions support data with 1-, 3-, or 4-channel pixel values. In the alpha channel case (AC4), the alpha channels are not processed.

### Arithmetic Operations

Functions described in this section perform arithmetic operations on pixel values. Arithmetic operations include addition, multiplication, subtraction, and division of pixel values of two images as well as similar operations on a single image and a constant. Computation of an absolute value, square, square root, exponential, and natural logarithm of pixels in an image buffer is also supported. Functions of this group perform operations on each pixel in the source buffer(s), and write the results into the destination buffer. Some functions also support processing of images with complex data.

**Add**

\textit{Adds pixel values of two images.}

**Syntax**

\texttt{IppStatus ippiAdd\_mod\_<mod>\(\text{<mod>}\)}\texttt{(const Ipp<datatype>\* pSrc1, int src1Step, const Ipp<datatype>\* pSrc2, int src2Step, Ipp<datatype>\* pDst, int dstStep, IppSize roiSize, int scaleFactor)};

\textbf{Supported values for} \texttt{mod}:

\begin{itemize}
  \item \texttt{8u\_C1RSfs} \quad \texttt{16u\_C1RSfs} \quad \texttt{16s\_C1RSfs}
  \item \texttt{8u\_C3RSfs} \quad \texttt{16u\_C3RSfs} \quad \texttt{16s\_C3RSfs}
  \item \texttt{8u\_C4RSfs} \quad \texttt{16u\_C4RSfs} \quad \texttt{16s\_C4RSfs}
  \item \texttt{8u\_AC4RSfs} \quad \texttt{16u\_AC4RSfs} \quad \texttt{16s\_AC4RSfs}
\end{itemize}
Case 2: Not-in-place operation on floating point or complex data

IppStatusippiAdd_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

32f_C1R
32f_C3R
32f_C4R

IppStatusippiAdd_32f_AC4R(const Ipp32f* pSrc1, int src1Step, const Ipp32f* pSrc2, int src2Step, Ipp32f* pDst, int dstStep, IppiSize roiSize);

Case 3: In-place operation on integer or complex data

IppStatusippiAdd_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs 16u_C1IRSfs 16s_C1IRSfs
8u_C3IRSfs 16u_C3IRSfs 16s_C3IRSfs
8u_AC4IRSfs 16u_AC4IRSfs 16s_AC4IRSfs
8u_C4IRSfs 16u_C4IRSfs 16s_C4IRSfs

Case 4: In-place operation on floating point or complex data

IppStatusippiAdd_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

32f_C1IR
32f_C3IR
32f_AC4IR
32f_C4IR

Case 5: In-place operation using a floating point accumulator image

IppStatusippiAdd_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u32f_C1IR 16u32f_C1IR
Case 6: Masked in-place operation using a floating point accumulator image

IppStatus ippiAdd_<mod>(const Ipp<srcDatatype> *pSrc, int srcStep, const Ipp8u* pMask, int maskStep, Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u32f_C1IMR 16u32f_C1IMR 32f_C1IMR

Case 7: Not-in-place operation on integer data with platform-aware functions

IppStatus ippiAdd_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, const Ipp<datatype>* pSrc2, IppSizeL src2Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1RSfs_L 16u_C1RSfs_L 16s_C1RSfs_L
8u_C3RSfs_L 16u_C3RSfs_L 16s_C3RSfs_L
8u_C4RSfs_L 16u_C4RSfs_L 16s_C4RSfs_L
8u_AC4RSfs_L 16u_AC4RSfs_L 16s_AC4RSfs_L

Case 8: Not-in-place operation on floating point data with platform-aware functions

IppStatus ippiAdd_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, const Ipp<datatype>* pSrc2, IppSizeL src2Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppiSizeL roiSize);

Supported values for mod:

32f_C1R_L
32f_C3R_L
32f_C4R_L
32f_AC4R_L

Case 9: In-place operation on integer data with platform-aware functions

IppStatus ippiAdd_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs_L 16u_C1IRSfs_L 16s_C1IRSfs_L
8u_C3IRSfs_L 16u_C3IRSfs_L 16s_C3IRSfs_L
8u_C4IRSfs_L 16u_C4IRSfs_L 16s_C4IRSfs_L
8u_AC4IRSfs_L 16u_AC4IRSfs_L 16s_AC4IRSfs_L
Case 10: In-place operation on floating point data with platform-aware functions

IppStatus ippiAdd_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize);

Supported values for mod:

32f_C1IR_L
32f_C3IR_L
32f_C4IR_L
32f_AC4IR_L

Case 11: Not-in-place operation on integer data with threading layer (TL) functions

IppStatus ippiAdd_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, const Ipp<datatype>* pSrc2, IppSizeL src2Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1RSfs_LT 16u_C1RSfs_LT 16s_C1RSfs_LT
8u_C3RSfs_LT 16u_C3RSfs_LT 16s_C3RSfs_LT
8u_C4RSfs_LT 16u_C4RSfs_LT 16s_C4RSfs_LT
8u_AC4RSfs_LT 16u_AC4RSfs_LT 16s_AC4RSfs_LT

Case 12: Not-in-place operation on floating point data with TL functions

IppStatus ippiAdd_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, const Ipp<datatype>* pSrc2, IppSizeL src2Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize);

Supported values for mod:

32f_C1R_LT
32f_C3R_LT
32f_C4R_LT
32f_AC4R_LT

Case 13: In-place operation on integer data with TL functions

IppStatus ippiAdd_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs_LT 16u_C1IRSfs_LT 16s_C1IRSfs_LT
8u_C3IRSfs_LT 16u_C3IRSfs_LT 16s_C3IRSfs_LT
8u_C4IRSfs_LT 16u_C4IRSfs_LT 16s_C4IRSfs_LT
Case 14: In-place operation on floating point data with TL functions

```c
IppStatus ippiAdd_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppiSizeL roiSize);
```

Supported values for `mod`:

- `32f_C1IR_LT`
- `32f_C3IR_LT`
- `32f_C4IR_LT`
- `32f_AC4IR_LT`

**Include Files**

- `ippcv.h`
- `ippi.h`
- `ippi_l.h`
- `ippi_tl.h`

**Domain Dependencies**

Flavors declared in `ippi.h`:

Headers: `ippcore.h`, `ippvm.h`, `ipps.h`
Libraries: `ippcore.lib`, `ippvm.lib`, `ipps.lib`

Flavors declared in `ippcv.h`:

Headers: `ippcore.h`, `ippvm.h`, `ipps.h`, `ippi.h`
Libraries: `ippcore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`

Flavors declared in `ippi64x.h`:


**Parameters**

- `pSrc`, `pSrc1`, `pSrc2`
- `srcStep`, `src1Step`, `src2Step`
- `pDst`
- `dstStep`
- `pSrc`
- `srcStep`
- `pSrcDst` 

Pointer to the ROI in the source images.

Distance, in bytes, between the starting points of consecutive lines in the source images.

Pointer to the destination image ROI.

Distance, in bytes, between the starting points of consecutive lines in the destination image.

Pointer to the first source image ROI for the in-place operation.

Distance, in bytes, between the starting points of consecutive lines in the first source image for the in-place operation.

Pointer to the second source and destination image ROI for the in-place operation.
**Description**

This function operates with ROI.

This function adds corresponding pixel values of two source image buffers and places the results in a destination buffer. In case of operations on integer data, the resulting values are scaled by `scaleFactor`. For complex data, the function processes both real and imaginary parts of pixel values. Some function flavors add `8u`, `8s`, `16u`, or `32f` source image pixel values to a floating point accumulator image in-place. Addition of pixel values in case of a masked operation is performed only if the respective mask value is non-zero; otherwise, the accumulator pixel value remains unchanged.

**NOTE**

For the functions that operate on complex data, step values must be positive. For the functions that use an accumulator image, step values must be no less than `roiSize.width*<pixelSize>`.

Functions with `AC4` descriptor do not process alpha channels.

Function flavors described in Case 5 and Case 6 are declared in the `ippcv.h`.

**Return Values**

`ippStsNoErr` Indicates no error. Any other value indicates an error or a warning.

`ippStsNullPtrErr` Indicates an error condition when any of the specified pointers is `NULL`.

`ippStsSizeErr` Indicates an error condition when `roiSize` has a field with zero or negative value.

`ippStsStepErr` Indicates an error condition in the following cases:

- For functions that operate on complex data, if any of the specified step values is zero or negative.
- For functions using an accumulator image, if any of the specified step values is less than `roiSize.width*<pixelSize>`.

`ippStsNotEvenStepErr` Indicates an error condition when one of step values for floating-point images cannot be divided by 4.

**Example**

The code example below shows how to use the function `ippiAdd_8u_C1RSfs`.

```c
Ipp8u src1[8*4] = {8, 4, 2, 1, 0, 0, 0,
                    8, 4, 2, 1, 0, 0, 0,
                    8, 4, 2, 1, 0, 0, 0,
                    ...
```
Ipp8u src2[8*4] = {4, 3, 2, 1, 0, 0, 0, 0, 
4, 3, 2, 1, 0, 0, 0, 0, 
4, 3, 2, 1, 0, 0, 0, 0, 
4, 3, 2, 1, 0, 0, 0, 0};
Ipp8u dst[8*4];
IppiSize srcRoi = { 4, 4 };
Int scaleFactor = 1;    // later examples for 2 and -2 values
ippiAdd_8u_C1RSfs (src1, 8, src2, 8, dst, 4, srcRoi, scaleFactor );
Result:
src1                src2
8 4 2 1 0 0 0 0    4 3 2 1 0 0 0 0
8 4 2 1 0 0 0 0    4 3 2 1 0 0 0 0
8 4 2 1 0 0 0 0    4 3 2 1 0 0 0 0
8 4 2 1 0 0 0 0    4 3 2 1 0 0 0 0
dst >>    scaleFactor = 1        scaleFactor = 2    ScaleFactor = -2
6 4 2 1            3 2 1 0        48 28 16 8
6 4 2 1            3 2 1 0        48 28 16 8
6 4 2 1            3 2 1 0        48 28 16 8
6 4 2 1            3 2 1 0        48 28 16 8
See Also
Regions of Interest in Intel IPP

AddC
Adds a constant to pixel values of an image.

Syntax
Case 1: Not-in-place operation on one-channel integer or complex data
IppStatus ippiAddC_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype> value, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:
8u_C1RSfs       16u_C1RSfs       16s_C1RSfs

Case 2: Not-in-place operation on multi-channel integer or complex data
IppStatus ippiAddC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:
8u_C3RSfs       16u_C3RSfs       16s_C3RSfs
IppStatus ippiAddC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype>* value[4], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C4RSfs  16u_C4RSfs  16s_C4RSfs

IppStatus ippiAddC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype>* value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_AC4RSfs  16u_AC4RSfs  16s_AC4RSfs

Case 3: Not-in-place operation on one-channel floating-point or complex data
IppStatus ippiAddC_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* value, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

32f_C1R

Case 4: Not-in-place operation on multi-channel floating-point or complex data
IppStatus ippiAddC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype>* value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

32f_C3R

IppStatus ippiAddC_32f_C4R(const Ipp32f* pSrc, int srcStep, const Ipp32f value[4], Ipp32f* pDst, int dstStep, IppiSize roiSize);

IppStatus ippiAddC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype>* value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

32f_AC4R

Case 5: In-place operation on one-channel integer or complex data
IppStatus ippiAddC_<mod>(Ipp<datatype> value, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs  16u_C1IRSfs  16s_C1IRSfs
Case 6: In-place operation on multi-channel integer or complex data

IppStatus ippiAddC_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

| 8u_C3IRSfs | 16u_C3IRSfs | 16s_C3IRSfs |
| 8u_AC4IRSfs | 16u_AC4IRSfs | 16s_AC4IRSfs |

IppStatus ippiAddC_<mod>(const Ipp<datatype> value[4], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

| 8u_C4IRSfs | 16u_C4IRSfs | 16s_C4IRSfs |

Case 7: In-place operation on one-channel floating-point or complex data

IppStatus ippiAddC_32f_C1IR(Ipp32f value, Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize);

Case 8: In-place operation on multi-channel floating-point or complex data

IppStatus ippiAddC_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

| 32f_C3IR |
| 32f_AC4IR |

IppStatus ippiAddC_32f_C4IR(const Ipp32f value[4], Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize);

Case 9: Not-in-place operation on one-channel integer data with platform-aware functions

IppStatus ippiAddC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

| 8u_C1RSfs_L | 16u_C1RSfs_L | 16s_C1RSfs_L |

Case 10: Not-in-place operation on multi-channel integer data with platform-aware functions

IppStatus ippiAddC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, const Ipp<datatype> value[3], Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

| 8u_C3RSfs_L | 16u_C3RSfs_L | 16s_C3RSfs_L |
| 8u_AC4RSfs_L | 16u_AC4RSfs_L | 16s_AC4RSfs_L |
IppStatus ippiAddC_<mod>(const Ippdatatype* pSrc, IppSizeL srcStep, const Ippdatatype> value[4], Ippdatatype* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C4RSfs_L    16u_C4RSfs_L    16s_C4RSfs_L

Case 11: Not-in-place operation on one-channel floating point data with platform-aware functions

IppStatus ippiAddC_32f_C1R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f value, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize);

Case 12: Not-in-place operation on multi-channel floating point data with platform-aware functions

IppStatus ippiAddC_<mod>(const Ipp32f* pSrc, IppSizeL srcStep, const Ipp32f value[3], Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize);

Supported values for mod:

32f_C3R_L
32f_AC4R_L

IppStatus ippiAddC_32f_C4R_L(const Ipp32f* pSrc, IppSizeL srcStep, const Ipp32f value[4], Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize);

Case 13: In-place operation on one-channel integer data with platform-aware functions

IppStatus ippiAddC_<mod>(const Ippdatatype> value, Ippdatatype* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs_L    16u_C1IRSfs_L    16s_C1IRSfs_L

Case 14: In-place operation on multi-channel integer data with platform-aware functions

IppStatus ippiAddC_<mod>(const Ippdatatype> value[3], Ippdatatype* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C3IRSfs_L    16u_C3IRSfs_L    16s_C3IRSfs_L
8u_AC4IRSfs_L    16u_AC4IRSfs_L    16s_AC4IRSfs_L

IppStatus ippiAddC_<mod>(const Ippdatatype> value[4], Ippdatatype* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C4IRSfs_L    16u_C4IRSfs_L    16s_C4IRSfs_L

Case 15: In-place operation on one-channel floating point data with platform-aware functions

IppStatus ippiAddC_32f_C1IR_L(Ipp32f value, Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);
Case 16: In-place operation on multi-channel integer data with platform-aware functions

IppStatus ippiAddC_<mod>(const Ipp32f value[3], Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);

Supported values for mod:

- 32f_C3IR_L
- 32f_AC4IR_L

IppStatus ippiAddC_32f_C4IR_L(const Ipp32f value[4], Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);

Case 17: Not-in-place operation on one-channel integer data with threading layer (TL) functions

IppStatus ippiAddC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype> value, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

- 8u_C1RSfs_LT
- 16u_C1RSfs_LT
- 16s_C1RSfs_LT

Case 18: Not-in-place operation on multi-channel integer data with TL functions

IppStatus ippiAddC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, const Ipp<datatype> value[3], Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

- 8u_C3RSfs_LT
- 16u_C3RSfs_LT
- 16s_C3RSfs_LT
- 8u_AC4RSfs_LT
- 16u_AC4RSfs_LT
- 16s_AC4RSfs_LT

IppStatus ippiAddC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, const Ipp<datatype> value[4], Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

- 8u_C4RSfs_LT
- 16u_C4RSfs_LT
- 16s_C4RSfs_LT

Case 19: Not-in-place operation on one-channel floating point data with TL functions

IppStatus ippiAddC_32f_C1R_LT(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f value, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize);

Case 20: Not-in-place operation on multi-channel floating point data with TL functions

IppStatus ippiAddC_<mod>(const Ipp32f* pSrc, IppSizeL srcStep, const Ipp32f value[3], Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize);

Supported values for mod:

- 32f_C3R_LT
- 32f_AC4R_LT
Case 21: In-place operation on one-channel integer data with TL functions

IppStatus ippiAddC_<mod>(Ipp<datatype> value, Ipp<datatype> pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs_LT  16u_C1IRSfs_LT  16s_C1IRSfs_LT

Case 22: In-place operation on multi-channel integer data with TL functions

IppStatus ippiAddC_<mod>(const Ipp<datatype> value[3], Ipp<datatype> pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C3IRSfs_LT  16u_C3IRSfs_LT  16s_C3IRSfs_LT
8u_AC4IRSfs_LT  16u_AC4IRSfs_LT  16s_AC4IRSfs_LT

Case 23: In-place operation on one-channel floating point data with TL functions

IppStatus ippiAddC_32f_C1IR_LT(Ipp32f value, Ipp32f pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);

Case 24: In-place operation on multi-channel integer data with TL functions

IppStatus ippiAddC_<mod>(const Ipp32f value[3], Ipp32f pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);

Supported values for mod:

32f_C3IR_LT
32f_AC4IR_LT

IppStatus ippiAddC_32f_C4IR_LT(const Ipp32f value[4], Ipp32f pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);

Include Files

ippi.h

Flavors with the _LT suffix: ippi_tl.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Flavors declared in ippi.h:

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:

Parameters

pSrc
Pointer to the source image ROI.

srcStep
Distance in bytes between starts of consecutive lines in the source image.

value
The constant value to add to image pixel values (constant vector in case of multi-channel images).

pDst
Pointer to the destination image ROI.

dstStep
Distance in bytes between starts of consecutive lines in the destination image.

pSrcDst
Pointer to the source and destination image ROI for the in-place operation.

srcDstStep
Distance in bytes between starts of consecutive lines in the source and destination image buffer for the in-place operation.

roiSize
Size of the source and destination ROI in pixels.

scaleFactor
Scale factor (see Integer Result Scaling).

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function changes the image intensity by adding value to image pixel values. For one-channel images, a positive value brightens the image (increases the intensity); a negative value darkens the image (decreases the intensity). For multi-channel images, the components of a constant vector value are added to pixel channel values. For complex data, the function processes both real and imaginary parts of pixel values.

NOTE
Step values must be positive for functions that operate on complex data.

In case of operations on integer data, the resulting values are scaled by scaleFactor.

Note that the functions with AC4 descriptor do not process alpha channels.

Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr
Indicates an error condition if any of the specified pointers is NULL.

ippStsSizeErr
Indicates an error condition if roiSize has a field with zero or negative value.

ippStsStepErr
Indicates an error condition if any of the specified buffer step values is zero or negative for functions that operate on complex data.
AddSquare

Adds squared pixel values of a source image to floating-point pixel values of an accumulator image.

Syntax

Case 1: In-place operation

IppStatus ippiAddSquare_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u32f_C1IR  16u32f_C1IR  32f_C1IR

Case 2: Masked in-place operation

IppStatus ippiAddSquare_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, const Ipp8u* pMask, int maskStep, Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u32f_C1IMR  16u32f_C1IMR  32f_C1IMR

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc
Pointer to the source image ROI.

srcStep
Distance in bytes between starts of consecutive lines in the source image.

pMask
Pointer to the mask image.

maskStep
Distance in bytes between starts of consecutive lines in the mask image.

pSrcDst
Pointer to the destination (accumulator) image ROI.

srcDstStep
Distance in bytes between starts of consecutive lines in the accumulator image.

roiSize
Size of the image ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function adds squared pixel values of the source image pSrc to floating-point pixel values of the accumulator image pSrcDst as follows:

\[ pSrcDst(x,y) = pSrcDst(x,y) + pSrc(x,y)^2 \]
Addition of the squared pixel values in case of a masked operation is performed only if the respective mask value is nonzero; otherwise, the accumulator pixel value remains unchanged.

### Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if any of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error when `roiSize.width` or `roiSize.height` is negative.
- **ippStsStepErr**: Indicates an error when `srcStep`, `maskStep`, or `srcDstStep` is less than `roiSize.width * <pixelSize>`.
- **ippStsNotEvenStepErr**: Indicates an error condition if one of step values for floating-point images cannot be divided by 4.

### AddProduct

Adds product of pixel values of two source images to floating-point pixel values of an accumulator image.

### Syntax

**Case 1: In-place operation**

```c
IppStatus ippiAddProduct_<mod>(const Ipp<srcDatatype>* pSrc1, int src1Step, const Ipp<srcDatatype>* pSrc2, int src2Step, Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize);
```

Supported values for `mod`:

- `8u32f_C1IR`
- `16u32f_C1IR`
- `32f_C1IR`

**Case 2: Masked in-place operation**

```c
IppStatus ippiAddProduct_<mod>(const Ipp<srcDatatype>* pSrc1, int src1Step, const Ipp<srcDatatype>* pSrc2, int src2Step, const Ipp8u* pMask, int maskStep, Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize);
```

Supported values for `mod`:

- `8u32f_C1IMR`
- `16u32f_C1IMR`
- `32f_C1IMR`

### Include Files

- `ippcv.h`

### Domain Dependencies

**Headers**: `ippcore.h`, `ippvm.h`, `ipps.h`, `ippi.h`

**Libraries**: `ippcore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`

### Parameters

- `pSrc1`, `pSrc2`: Pointers to the source images ROI.
AddWeighted

This function operates with ROI (see Regions of Interest in Intel IPP).

This function adds the product of pixel values of two source images \( p_{\text{Src1}} \) and \( p_{\text{Src2}} \) to floating-point pixel values of the accumulator image \( p_{\text{SrcDst}} \) as given by:

\[
p_{\text{SrcDst}}(x,y) = p_{\text{SrcDst}}(x,y) + p_{\text{Src1}}(x,y) \times p_{\text{Src2}}(x,y)
\]

The products of pixel values in case of a masked operation are added only if the respective mask value is nonzero; otherwise, the accumulator pixel value remains unchanged.

**Return Values**

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error when any of the specified pointers is null.
- ippStsSizeErr: Indicates an error when \( \text{roiSize}.width \) or \( \text{roiSize}.height \) is negative.
- ippStsStepErr: Indicates an error if \( \text{srcStep}, \text{src2Step}, \text{maskStep}, \) or \( \text{srcDdstStep} \) is less than \( \text{roiSize}.width \times \text{<pixelSize>} \).
- ippStsNotEvenStepErr: Indicates an error condition if one of step values for floating-point images cannot be divided by 4.

**AddWeighted**

Adds weighted pixel values of a source image to floating-point pixel values of an accumulator image.

**Syntax**

**Case 1: In-place operation**

```c
IppStatus ippAddWeighted_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp32f alpha);
```

Supported values for \( \text{mod} \):

- 8u32f_C1IR
- 16u32f_C1IR
- 32f_C1IR
Case 2: Masked in-place operation

IppStatus ippiAddWeighted_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, const Ipp8u* pMask, int maskStep, Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp32f alpha);

Supported values for mod:

- 8u32f_C1IMR
- 16u32f_C1IMR
- 32f_C1IMR

Case 3: Not-in-place operation

IppStatus ippiAddWeighted_32f_C1R(const Ipp32f* pSrc1, int src1Step, const Ipp32f* pSrc2, int src2Step, Ipp32f* pDst, int dstStep, IppiSize roiSize, Ipp32f alpha);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- pSrc: Pointer to the source image ROI for the in-place operation.
- pSrc1, pSrc2: Pointers to the ROI in the source images.
- srcStep: Distance in bytes between starts of consecutive lines in the source image for the in-place operation.
- src1Step, src2Step: Distance in bytes between starts of consecutive lines in the source images.
- pMask: Pointer to the mask image.
- maskStep: Distance in bytes between starts of consecutive lines in the mask image.
- pSrcDst: Pointer to the destination (accumulator) image ROI for the in-place operation.
- srcDstStep: Distance in bytes between starts of consecutive lines in the accumulator image.
- pDst: Pointer to the destination image ROI.
- dstStep: Distance in bytes between starts of consecutive lines in the destination image.
- roiSize: Size of the image ROI in pixels.
- alpha: Weight a of the source image.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function adds pixel values of the source image pSrc1 multiplied by a weight factor alpha to pixel values of the image pSrc2 multiplied by (1-alpha) and stores result in the pDst as follows:

\[ pDst(x,y) = pSrc1(x,y) \times alpha + pSrc2(x,y) \times (1 - alpha). \]
The in-place flavors of the function adds pixel values of the source image \( p_{Src} \) multiplied by a weight factor \( \alpha \) to floating-point pixel values of the accumulator image \( p_{SrcDst} \) multiplied by \((1-\alpha)\) as follows:

\[
p_{SrcDst}(x,y) = p_{SrcDst}(x,y) \times (1-\alpha) + p_{Src}(x,y) \times \alpha
\]

Addition of the weighted pixel values in case of a masked operation is performed only if the respective mask value is nonzero; otherwise, the accumulator pixel value remains unchanged.

**Return Values**

- `ippStsNoErr` Indicates no error.
- `ippStsNullPtrErr` Indicates an error when any of the specified pointers is `NULL`.
- `ippStsSizeErr` Indicates an error when \( roiSize.width \) or \( roiSize.height \) is equal to 0 or negative.
- `ippStsStepErr` Indicates an error when one of the step values is equal to zero, or is less than \( roiSize.width \times \text{<pixelSize>} \).
- `ippStsNotEvenStepErr` Indicates an error when one of step values for floating-point images cannot be divided by 4.

**Mul**

*Multiples pixel values of two images.*

**Case 1: Not-in-place operation on integer or complex data**

\[
IppStatus ippiMul_{<mod>}(\text{ const Ipp<datatype>* } p_{Src1}, \text{ int } src1Step, \text{ const Ipp<datatype>* } p_{Src2}, \text{ int } src2Step, \text{ Ipp<datatype>* } p_{Dst}, \text{ int } dstStep, \text{ IppiSize } roiSize, \text{ int scaleFactor});
\]

**Supported values for mod:**

- \( 8u_{C1RSfs} \)
- \( 8u_{C3RSfs} \)
- \( 8u_{AC4RSfs} \)
- \( 8u_{C4RSfs} \)
- \( 16u_{C1RSfs} \)
- \( 16u_{C3RSfs} \)
- \( 16u_{AC4RSfs} \)
- \( 16u_{C4RSfs} \)
- \( 16s_{C1RSfs} \)
- \( 16s_{C3RSfs} \)
- \( 16s_{AC4RSfs} \)
- \( 16s_{C4RSfs} \)

**Case 2: Not-in-place operation on floating-point or complex data**

\[
IppStatus ippiMul_{<mod>}(\text{ const Ipp<datatype>* } p_{Src1}, \text{ int } src1Step, \text{ const Ipp<datatype>* } p_{Src2}, \text{ int } src2Step, \text{ Ipp<datatype>* } p_{Dst}, \text{ int } dstStep, \text{ IppiSize } roiSize);\]

**Supported values for mod:**

- \( 32f_{C1R} \)
- \( 32f_{AC4R} \)
- \( 32f_{C3R} \)
- \( 32f_{C4R} \)
Case 3: In-place operation on integer or complex data

IppStatus ippiMul_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pSrcDst, int srcDstStep, IppSize roiSize, int scaleFactor);

Supported values for mod:

- 8u_C1IRSfs
- 16u_C1IRSfs
- 16s_C1IRSfs
- 8u_C3IRSfs
- 16u_C3IRSfs
- 16s_C3IRSfs
- 8u_AC4IRSfs
- 16u_AC4IRSfs
- 16s_AC4IRSfs
- 8u_C4IRSfs
- 16u_C4IRSfs
- 16s_C4IRSfs

Case 4: In-place operation on floating-point or complex data

IppStatus ippiMul_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pSrcDst, int srcDstStep, IppSize roiSize);

Supported values for mod:

- 32f_C1IR
- 32f_C3IR
- 32f_AC4IR
- 32f_C4IR

Case 5: Not-in-place operation on integer data with platform-aware functions

IppStatus ippiMul_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, const Ipp<datatype>* pSrc2, IppSizeL src2Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

- 8u_C1RSfs_L
- 16u_C1RSfs_L
- 16s_C1RSfs_L
- 8u_C3RSfs_L
- 16u_C3RSfs_L
- 16s_C3RSfs_L
- 8u_AC4RSfs_L
- 16u_AC4RSfs_L
- 16s_AC4RSfs_L
- 8u_C4RSfs_L
- 16u_C4RSfs_L
- 16s_C4RSfs_L

Case 6: Not-in-place operation on floating-point data with platform-aware functions

IppStatus ippiMul_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, const Ipp<datatype>* pSrc2, IppSizeL src2Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize);

Supported values for mod:

- 32f_C1R_L
- 32f_C3R_L
- 32f_C4R_L
Case 7: In-place operation on integer data with platform-aware functions

IppStatus ippiMul_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

- 8u_C1IRSfs_L
- 16u_C1IRSfs_L
- 16s_C1IRSfs_L
- 8u_C3IRSfs_L
- 16u_C3IRSfs_L
- 16s_C3IRSfs_L
- 8u_AC4IRSfs_L
- 16u_AC4IRSfs_L
- 16s_AC4IRSfs_L
- 8u_C4IRSfs_L
- 16u_C4IRSfs_L
- 16s_C4IRSfs_L

Case 8: In-place operation on floating-point data with platform-aware functions

IppStatus ippiMul_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);

Supported values for mod:

- 32f_C1IR_L
- 32f_C3IR_L
- 32f_AC4IR_L
- 32f_C4IR_L

Case 9: Not-in-place operation on integer data with threading layer (TL) functions

IppStatus ippiMul_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, const Ipp<datatype>* pSrc2, IppSizeL src2Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

- 8u_C1RSfs_LT
- 16u_C1RSfs_LT
- 16s_C1RSfs_LT
- 8u_C3RSfs_LT
- 16u_C3RSfs_LT
- 16s_C3RSfs_LT
- 8u_AC4RSfs_LT
- 16u_AC4RSfs_LT
- 16s_AC4RSfs_LT
- 8u_C4RSfs_LT
- 16u_C4RSfs_LT
- 16s_C4RSfs_LT

Case 10: Not-in-place operation on floating-point data with TL functions

IppStatus ippiMul_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, const Ipp<datatype>* pSrc2, IppSizeL src2Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize);

Supported values for mod:

- 32f_C1R_LT
- 32f_C3R_LT
Case 11: In-place operation on integer data with TL functions

```
IppStatus ippiMul_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize, int scaleFactor);
```

Supported values for `mod`:

- 8u_C1IRSfs_LT
- 16u_C1IRSfs_LT
- 16s_C1IRSfs_LT
- 8u_C3IRSfs_LT
- 16u_C3IRSfs_LT
- 16s_C3IRSfs_LT
- 8u_AC4IRSfs_LT
- 16u_AC4IRSfs_LT
- 16s_AC4IRSfs_LT
- 8u_C4IRSfs_LT
- 16u_C4IRSfs_LT
- 16s_C4IRSfs_LT

Case 12: In-place operation on floating-point data with TL functions

```
IppStatus ippiMul_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize);
```

Supported values for `mod`:

- 32f_C1IR_LT
- 32f_C3IR_LT
- 32f_AC4IR_LT
- 32f_C4IR_LT

Include Files

- ippi.h

*Flavors with the `_LT` suffix:* ippi_tl.h

*Flavors with the `_L` suffix:* ippi_l.h

Domain Dependencies

Flavors declared in ippi.h:

- Headers: ippcore.h, ippvm.h, ipps.h
- Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:


Parameters

- `pSrc, pSrc1, pSrc2`  
  Pointers to the source images ROI.
- `srcStep, src1Step, src2Step`  
  Distances in bytes between starts of consecutive lines in the source images.
- `pDst`  
  Pointer to the destination image ROI.
\textbf{Description}

This function operates with ROI (see Regions of Interest in Intel IPP).

This function multiplies corresponding pixel values of two source image buffers and places the results in a destination buffer. In case of operations on integer data, the resulting values are scaled by $\text{scaleFactor}$.

For complex data, the function processes both real and imaginary parts of pixel values.

\textbf{NOTE}

Step values must be positive for functions that operate on complex data.

Note that the functions with AC4 descriptor do not process alpha channels.

\textbf{Return Values}

- \texttt{ippStsNoErr} Indicates no error. Any other value indicates an error or a warning.
- \texttt{ippStsNullPtrErr} Indicates an error condition if any of the pointers is NULL.
- \texttt{ippStsSizeErr} Indicates an error condition if $\text{roiSize}$ has a field with zero or negative value.
- \texttt{ippStsStepErr} Indicates an error condition if any of the specified buffer step values is zero or negative for functions that operate on complex data.

\textbf{MulC}

\textit{Multiplies pixel values of an image by a constant.}

\textbf{Syntax}

\textbf{Case 1: Not-in-place operation on one-channel integer or complex data}

\begin{verbatim}
IppStatus ippiMulC_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype> value, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);
\end{verbatim}

Supported values for $\text{mod}$:

- $8u\_C1RSfs$
- $16u\_C1RSfs$
- $16s\_C1RSfs$
Case 2: Not-in-place operation on multi-channel integer or complex data

IppStatus ippiMulC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype>* value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C3RSfs  16u_C3RSfs  16s_C3RSfs

IppStatus ippiMulC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype>* value[4], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C4RSfs  16u_C4RSfs  16s_C4RSfs

IppStatus ippiMulC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype>* value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_AC4RSfs  16u_AC4RSfs  16s_AC4RSfs

Case 3: Not-in-place operation on one-channel floating-point or complex data

IppStatus ippiMulC_32f_C1R(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* value, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Case 4: Not-in-place operation on multi-channel floating-point or complex data

IppStatus ippiMulC_32f_C3R(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype>* value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

IppStatus ippiMulC_32f_C4R(const Ipp32f* pSrc, int srcStep, const Ipp32f value[4], Ipp32f* pDst, int dstStep, IppiSize roiSize);

IppStatus ippiMulC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype>* value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

32f_AC4R

IppStatus ippiMulC_32f_C4R(const Ipp32f* pSrc, int srcStep, const Ipp32f value[4], Ipp32f* pDst, int dstStep, IppiSize roiSize);

Case 5: In-place operation on one-channel integer or complex data

IppStatus ippiMulC_<mod>(Ipp<datatype> value, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs  16u_C1IRSfs  16s_C1IRSfs
Case 6: In-place operation on multi-channel integer or complex data

IppStatus ippiMulC_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C3IRSfs 16u_C3IRSfs 16s_C3IRSfs
8u_AC4IRSfs 16u_AC4IRSfs 16s_AC4IRSfs

IppStatus ippiMulC_<mod>(const Ipp<datatype> value[4], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C4IRSfs 16u_C4IRSfs 16s_C4IRSfs

Case 7: In-place operation on one-channel floating-point or complex data

IppStatus ippiMulC_32f_C1IR(Ipp32f value, Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize);

Case 8: In-place operation on multi-channel floating-point or complex data

IppStatus ippiMulC_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

32f_C3IR
32f_AC4IR

IppStatus ippiMulC_32f_C4IR(const Ipp32f value[4], Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize);

Case 9: Not-in-place operation on one-channel integer data with platform-aware functions

IppStatus ippiMulC_<mod>(const Ipp<datatype>* pSrc, IppSize srcStep, Ipp<datatype>* pDst, IppSize dstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C1RSfs_L 16u_C1RSfs_L 16s_C1RSfs_L

Case 10: Not-in-place operation on multi-channel integer data with platform-aware functions

IppStatus ippiMulC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, const Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C3RSfs_L 16u_C3RSfs_L 16s_C3RSfs_L
8u_AC4RSfs_L 16u_AC4RSfs_L 16s_AC4RSfs_L
The function `ippiMulC_<mod>` is used for multiplication operations on different types of data in various configurations.

**Case 11: Not-in-place operation on one-channel floating point data with platform-aware functions**

```c
IppStatus ippiMulC_32f_C1R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f value, Ipp32f* pDst, IppSizeL dstStep, IppiSizeL roiSize);
```

**Supported values for mod:**

- 32f_C3R_L
- 32f_AC4R_L

**Case 12: Not-in-place operation on multi-channel floating point data with platform-aware functions**

```c
IppStatus ippiMulC_<mod>(const Ipp32f* pSrc, IppSizeL srcStep, const Ipp32f value[3], Ipp32f* pDst, IppSizeL dstStep, IppiSizeL roiSize);
```

**Supported values for mod:**

- 32f_C3R_L
- 32f_AC4R_L

**Case 13: In-place operation on one-channel integer data with platform-aware functions**

```c
IppStatus ippiMulC_<mod>(Ipp<datatype> value, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize, int scaleFactor);
```

**Supported values for mod:**

- 8u_C1IRSfs_L
- 16u_C1IRSfs_L
- 16s_C1IRSfs_L

**Case 14: In-place operation on multi-channel integer data with platform-aware functions**

```c
IppStatus ippiMulC_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize, int scaleFactor);
```

**Supported values for mod:**

- 8u_C3IRSfs_L
- 16u_C3IRSfs_L
- 16s_C3IRSfs_L
- 8u_AC4IRSfs_L
- 16u_AC4IRSfs_L
- 16s_AC4IRSfs_L

**Case 15: In-place operation on one-channel floating point data with platform-aware functions**

```c
IppStatus ippiMulC_32f_C1R_L(Ipp32f value, Ipp32f* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize);
```
**Case 16: In-place operation on multi-channel integer data with platform-aware functions**

IppStatus ippiMulC_<mod>(const Ipp32f* value[3], Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);

Supported values for mod:

- 32f_C3IR_L
- 32f_AC4IR_L

IppStatus ippiMulC_32f_C4IR_L(const Ipp32f* value[4], Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);

**Case 17: Not-in-place operation on one-channel integer data with threading layer (TL) functions**

IppStatus ippiMulC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype> value, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

- 8u_C1RSfs_LT
- 16u_C1RSfs_LT
- 16s_C1RSfs_LT

**Case 18: Not-in-place operation on multi-channel integer data with TL functions**

IppStatus ippiMulC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, const Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

- 8u_C3RSfs_LT
- 16u_C3RSfs_LT
- 16s_C3RSfs_LT
- 8u_AC4RSfs_LT
- 16u_AC4RSfs_LT
- 16s_AC4RSfs_LT

IppStatus ippiMulC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, const Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

- 8u_C4RSfs_LT
- 16u_C4RSfs_LT
- 16s_C4RSfs_LT

**Case 19: Not-in-place operation on one-channel floating point data with TL functions**

IppStatus ippiMulC_32f_C1R_LT(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f value, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

**Case 20: Not-in-place operation on multi-channel floating point data with TL functions**

IppStatus ippiMulC_<mod>(const Ipp32f* pSrc, IppSizeL srcStep, const Ipp32f value[3], Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize);

Supported values for mod:

- 32f_C3R_LT
- 32f_AC4R_LT
IppStatus ippiMulC_32f_C4R_LT(const Ipp32f* pSrc, IppSizeL srcStep, const Ipp32f value[4], Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize);

**Case 21: In-place operation on one-channel integer data with TL functions**

IppStatus ippiMulC_<mod>({Ipp<datatype> value, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize, int scaleFactor});

Supported values for **mod**:

8u_C1IRSfs_LT  16u_C1IRSfs_LT  16s_C1IRSfs_LT

**Case 22: In-place operation on multi-channel integer data with TL functions**

IppStatus ippiMulC_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize, int scaleFactor);

Supported values for **mod**:

8u_C3IRSfs_LT  16u_C3IRSfs_LT  16s_C3IRSfs_LT
8u_AC4IRSfs_LT  16u_AC4IRSfs_LT  16s_AC4IRSfs_LT

IppStatus ippiMulC_<mod>(const Ipp<datatype> value[4], Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize, int scaleFactor);

Supported values for **mod**:

8u_C4IRSfs_LT  16u_C4IRSfs_LT  16s_C4IRSfs_LT

**Case 23: In-place operation on one-channel floating point data with TL functions**

IppStatus ippiMulC_32f_C1IR_LT(Ipp32f value, Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);

**Case 24: In-place operation on multi-channel integer data with TL functions**

IppStatus ippiMulC_<mod>(const Ipp32f value[3], Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);

Supported values for **mod**:

32f_C3IR_LT
32f_AC4IR_LT

IppStatus ippiMulC_32f_C4IR_LT(const Ipp32f value[4], Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);

**Include Files**

ippi.h

**Flavors with the **_LT** suffix:** ippi_tl.h

**Flavors with the **_L** suffix:** ippi_l.h

**Domain Dependencies**

Flavors declared in ippi.h:

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared inippi_t1.h:
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib,ippcore_t1.lib,ippi_t1.lib

**Parameters**

- **pSrc**
  Pointer to the source image ROI.

- **srcStep**
  Distance, in bytes, between the starting points of consecutive lines in the source image.

- **value**
  The constant value to add to image pixel values (constant vector in case of multi-channel images).

- **pDst**
  Pointer to the destination image ROI.

- **dstStep**
  Distance, in bytes, between the starting points of consecutive lines in the destination image.

- **pSrcDst**
  Pointer to the source and destination image ROI for the in-place operation.

- **srcDstStep**
  Distance, in bytes, between the starting points of consecutive lines in the source and destination image for the in-place operation.

- **roiSize**
  Size of the source and destination ROI in pixels.

- **scaleFactor**
  Scale factor (see Integer Result Scaling).

**Description**

This function operates with ROI (see Regions of Regions of Interest in Intel IPP).

This function multiplies pixel values of an image by a constant `value`. For multi-channel images, pixel channel values are multiplied by the components of a constant vector `value`. For complex data, the function processes both real and imaginary parts of pixel values.

**NOTE**

Step values must be positive for functions that operate on complex data.

In case of operations on integer data, the resulting values are scaled by `scaleFactor`.

Note that the functions with AC4 descriptor do not process alpha channels.

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**
  Indicates an error condition if any of the specified pointers is NULL.

- **ippStsSizeErr**
  Indicates an error condition if `roiSize` has a field with zero or negative value.

- **ippStsStepErr**
  Indicates an error condition if any of the specified buffer step values is zero or negative for functions that operate on complex data.
**MulC64f**

Multiplies pixel values of an image by a constant array.

**Syntax**

### Not-in-place operations

```
IppStatus ippiMulC64f_8u_C1R(const Ipp8u* pSrc, int srcStep, const Ipp64f value[1],
                            Ipp8u* pDst, int dstStep, IppiSize roiSize, IppHintAlgorithm hint,
                            IppRoundMode rndMode);

IppStatus ippiMulC64f_8u_C3R(const Ipp8u* pSrc, int srcStep, const Ipp64f value[3],
                            Ipp8u* pDst, int dstStep, IppiSize roiSize, IppHintAlgorithm hint,
                            IppRoundMode rndMode);

IppStatus ippiMulC64f_8u_C4R(const Ipp8u* pSrc, int srcStep, const Ipp64f value[4],
                            Ipp8u* pDst, int dstStep, IppiSize roiSize, IppHintAlgorithm hint,
                            IppRoundMode rndMode);

IppStatus ippiMulC64f_16u_C1R(const Ipp16u* pSrc, int srcStep, const Ipp64f value[1],
                            Ipp16u* pDst, int dstStep, IppiSize roiSize, IppHintAlgorithm hint,
                            IppRoundMode rndMode);

IppStatus ippiMulC64f_16u_C3R(const Ipp16u* pSrc, int srcStep, const Ipp64f value[3],
                            Ipp16u* pDst, int dstStep, IppiSize roiSize, IppHintAlgorithm hint,
                            IppRoundMode rndMode);

IppStatus ippiMulC64f_16u_C4R(const Ipp16u* pSrc, int srcStep, const Ipp64f value[4],
                            Ipp16u* pDst, int dstStep, IppiSize roiSize, IppHintAlgorithm hint,
                            IppRoundMode rndMode);

IppStatus ippiMulC64f_16s_C1R(const Ipp16s* pSrc, int srcStep, const Ipp64f value[1],
                            Ipp16s* pDst, int dstStep, IppiSize roiSize, IppHintAlgorithm hint,
                            IppRoundMode rndMode);

IppStatus ippiMulC64f_16s_C3R(const Ipp16s* pSrc, int srcStep, const Ipp64f value[3],
                            Ipp16s* pDst, int dstStep, IppiSize roiSize, IppHintAlgorithm hint,
                            IppRoundMode rndMode);

IppStatus ippiMulC64f_16s_C4R(const Ipp16s* pSrc, int srcStep, const Ipp64f value[4],
                            Ipp16s* pDst, int dstStep, IppiSize roiSize, IppHintAlgorithm hint,
                            IppRoundMode rndMode);

IppStatus ippiMulC64f_32f_C1R(const Ipp32f* pSrc, int srcStep, const Ipp64f value[1],
                            Ipp32f* pDst, int dstStep, IppiSize roiSize, IppHintAlgorithm hint,
                            IppRoundMode rndMode);

IppStatus ippiMulC64f_32f_C3R(const Ipp32f* pSrc, int srcStep, const Ipp64f value[3],
                            Ipp32f* pDst, int dstStep, IppiSize roiSize, IppHintAlgorithm hint,
                            IppRoundMode rndMode);
```
IppStatus ippiMulC64f_32f_C4R(const Ipp32f* pSrc, int srcStep, const Ipp64f value[4],
Ipp32f* pDst, int dstStep, IppiSize roiSize, IppHintAlgorithm hint, IppRoundMode
rndMode);

In-place operations
IppStatus ippiMulC64f_8u_C1IR(Ipp8u* pSrcDst, int srcDstStep, const Ipp64f value[1],
IppiSize roiSize, IppHintAlgorithm hint, IppRoundMode rndMode);
IppStatus ippiMulC64f_8u_C3IR(Ipp8u* pSrcDst, int srcDstStep, const Ipp64f value[3],
IppiSize roiSize, IppHintAlgorithm hint, IppRoundMode rndMode);
IppStatus ippiMulC64f_8u_C4IR(Ipp8u* pSrcDst, int srcDstStep, const Ipp64f value[4],
IppiSize roiSize, IppHintAlgorithm hint, IppRoundMode rndMode);
IppStatus ippiMulC64f_16u_C1IR(Ipp16u* pSrcDst, int srcDstStep, const Ipp64f value[1],
IppiSize roiSize, IppHintAlgorithm hint, IppRoundMode rndMode);
IppStatus ippiMulC64f_16u_C3IR(Ipp16u* pSrcDst, int srcDstStep, const Ipp64f value[3],
IppiSize roiSize, IppHintAlgorithm hint, IppRoundMode rndMode);
IppStatus ippiMulC64f_16u_C4IR(Ipp16u* pSrcDst, int srcDstStep, const Ipp64f value[4],
IppiSize roiSize, IppHintAlgorithm hint, IppRoundMode rndMode);
IppStatus ippiMulC64f_16s_C1IR(Ipp16s* pSrcDst, int srcDstStep, const Ipp64f value[1],
IppiSize roiSize, IppHintAlgorithm hint, IppRoundMode rndMode);
IppStatus ippiMulC64f_16s_C3IR(Ipp16s* pSrcDst, int srcDstStep, const Ipp64f value[3],
IppiSize roiSize, IppHintAlgorithm hint, IppRoundMode rndMode);
IppStatus ippiMulC64f_16s_C4IR(Ipp16s* pSrcDst, int srcDstStep, const Ipp64f value[4],
IppiSize roiSize, IppHintAlgorithm hint, IppRoundMode rndMode);
IppStatus ippiMulC64f_32f_C1IR(Ipp32f* pSrcDst, int srcDstStep, const Ipp64f value[1],
IppiSize roiSize, IppHintAlgorithm hint, IppRoundMode rndMode);
IppStatus ippiMulC64f_32f_C3IR(Ipp32f* pSrcDst, int srcDstStep, const Ipp64f value[3],
IppiSize roiSize, IppHintAlgorithm hint, IppRoundMode rndMode);
IppStatus ippiMulC64f_32f_C4IR(Ipp32f* pSrcDst, int srcDstStep, const Ipp64f value[4],
IppiSize roiSize, IppHintAlgorithm hint, IppRoundMode rndMode);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc
Pointer to the source image.
pSrcDst
Pointer to the source and destination image ROI for in-place operations.
srStep
Distance, in bytes, between the starting points of consecutive lines in the source image.
srcDstStep
Distance, in bytes, between the starting points of consecutive lines in the source and destination image for in-place operations.
value

Constant vector to add to image pixel values.

pDst

Pointer to the destination image.

dstStep

Distance, in bytes, between the starting points of consecutive lines in the destination image.

roiSize

Size of the image ROI, in pixels.

hint

Option to select the algorithmic implementation of the function, the following values are supported:

- ippAlgHintAccurate: All output pixels are exact; accuracy takes precedence over performance.
- ippAlgHintFast: Function performance takes precedence over accuracy and some output pixels can differ by +/-1 from the exact result.
- ippAlgHintNone

rndMode

Rounding mode, the following values are supported:

- ippRndZero: Floating-point values are truncated to zero.
- ippRndNear: Floating-point values are rounded to the nearest even integer when the fractional part equals 0.5; otherwise they are rounded to the nearest integer.
- ippRndFinancial: Floating-point values are rounded down to the nearest integer when the fractional part is less than 0.5, or rounded up to the nearest integer if the fractional part is equal to or greater than 0.5.

Description

This function multiplies pixel values of the source image by the specified constant array and places the scaled results to the same image.

Return Values

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error when at least one of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error when width or height of the image is less than, or equal to zero.

Example

To better understand usage of this function, refer to the MulC64f.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

MulScale

*Multiplies pixel values of two images and scales the products.*
Syntax

Case 1: Not-in-place operation

IppStatus ippiMulScale_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

8u_C1R     16u_C1R
8u_C3R     16u_C3R
8u_C4R     16u_C4R
8u_AC4R    16u_AC4R

Case 2: In-place operation

IppStatus ippiMulScale_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u_C1IR    16u_C1IR
8u_C3IR    16u_C3IR
8u_C4IR    16u_C4IR
8u_AC4IR   16u_AC4IR

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc, pSrc1, pSrc2
srcStep, src1Step, src2Step

pDst
dstStep

pSrcDst
srcDstStep

roiSize

Pointers to the source images ROI.
Distances in bytes between starts of consecutive lines in the source images.
Pointer to the destination image ROI.
Distance in bytes between starts of consecutive lines in the destination image.
Pointer to the source and destination image ROI for the in-place operation.
Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.
Size of the source and destination ROI in pixels.
Description
This function operates with ROI (see Regions of Regions of Interest in Intel IPP).

This function multiplies corresponding pixel values of two input buffers and scales the products using the following formula:

\[
dst_{\text{pixel}} = \frac{src1_{\text{pixel}} \times src2_{\text{pixel}}}{\text{max}_\text{val}},
\]

where \( src1_{\text{pixel}} \) and \( src2_{\text{pixel}} \) are pixel values of the source buffers, \( dst_{\text{pixel}} \) is the resultant pixel value, and \( \text{max}_\text{val} \) is the maximum value of the pixel data range (see Table "Image Data Types and Ranges" for details). The function is implemented for 8-bit and 16-bit unsigned data types only.

Note that the functions with AC4 descriptor do not process alpha channelss.

Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error or a warning.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error condition if any of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error condition if ( roiSize ) has a field with zero or negative value.</td>
</tr>
<tr>
<td>ippStsStepErr</td>
<td>Indicates an error condition if any of the specified buffer step values is zero or negative.</td>
</tr>
</tbody>
</table>

MulCScale

Multiplies pixel values of an image by a constant and scales the products.

Syntax

Case 1: Not-in-place operation on one-channel data

```
IppStatus ippiMulCScale_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype> value, Ipp<datatype>* pDst, int dstStep, IppSize roiSize);
```

Supported values for \( mod \):

- 8u_C1R
- 16u_C1R

Case 2: Not-in-place operation on multi-channel data

```
IppStatus ippiMulCScale_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[3], Ipp<datatype>* pDst, int dstStep, IppSize roiSize);
```

Supported values for \( mod \):

- 8u_C3R
- 16u_C3R
- 8u_AC4R
- 16u_AC4R
IppStatus ippiMulCScale_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[4], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

8u_C4R   16u_C4R

**Case 3: In-place operation on one-channel data**

IppStatus ippiMulCScale_<mod>(Ipp<datatype> value, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u_C1IR   16u_C1IR

**Case 4: In-place operation on multi-channel data**

IppStatus ippiMulCScale_<mod>(const Ipp<datatype> value[3], const Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u_C3IR   16u_C3IR
8u_AC4IR   16u_AC4IR

IppStatus ippiMulCScale_<mod>(const Ipp<datatype> value[4], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u_C4IR   16u_C4IR

**Include Files**

ippi.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **pSrc**
  - Pointer to the source image ROI.
- **srcStep**
  - Distance in bytes between starts of consecutive lines in the source image.
- **value**
  - The constant value to multiply each pixel value in a source image (constant vector in case of 3- or four-channel images).
- **pDst**
  - Pointer to the destination image ROI.
- **dstStep**
  - Distance in bytes between starts of consecutive lines in the destination image.
- **pSrcDst**
  - Pointer to the source and destination image ROI for the in-place operation.
**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function multiplies pixel values in the input buffer by a constant \textit{value} and scales the products using the following formula:

\[ \text{dst\_pixel} = \text{src\_pixel} \times \text{value} \div \text{max\_val}, \]

where \textit{src\_pixel} is a pixel values of the source buffer, \textit{dst\_pixel} is the resultant pixel value, and \textit{max\_val} is the maximum value of the pixel data range (see Table “Image Data Types and Ranges” for details).

The function is implemented for 8-bit and 16-bit unsigned data types only. It can be used to multiply pixel values by a number between 0 and 1.

Note that the functions with \textit{AC4} descriptor do not process alpha channelss.

**Return Values**

\begin{itemize}
  \item \textbf{ippStsNoErr} indicates no error. Any other value indicates an error or a warning.
  \item \textbf{ippStsNullPtrErr} Indicates an error condition if one of the specified pointers is NULL.
  \item \textbf{ippStsSizeErr} Indicates an error condition if the \textit{roiSize} has a field with zero or negative value.
  \item \textbf{ippStsStepErr} Indicates an error condition if any of the specified buffer step values is zero or negative.
\end{itemize}

**Example**

The code example below shows how to use the function \textit{ippiMulCScale_8u_C1R}.

```c
void func_mulcscale()
{
    IppiSize ROI = {8,4};
    IppiSize ROI2 = {5,4};
    Ipp8u src[8*4];
    Ipp8u dst[8*4];
    Ipp8u v = 100;

    ippiSet_8u_C1R(100,src,8,ROI);
    ippiSet_8u_C1R(0,dst,8,ROI);
    ippiMulCScale_8u_C1R(src,8,v,dst,8,ROI2);
}
```

Result:

<table>
<thead>
<tr>
<th>src1</th>
<th>dst</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 100 100 100 100 100 100</td>
<td>39 39 39 39 0 0 0</td>
</tr>
<tr>
<td>100 100 100 100 100 100 100 100</td>
<td>39 39 39 39 0 0 0 0</td>
</tr>
<tr>
<td>100 100 100 100 100 100 100</td>
<td>39 39 39 39 0 0 0 0</td>
</tr>
<tr>
<td>100 100 100 100 100 100 100</td>
<td>39 39 39 39 0 0 0</td>
</tr>
<tr>
<td>100 100 100 100 100 100 100 100</td>
<td>39 39 39 39 0 0 0</td>
</tr>
</tbody>
</table>

**srcDstStep**

Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.

**roiSize**

Size of the source and destination ROI in pixels.
**Sub**

Subtracts pixel values of two images.

**Syntax**

**Case 1: Not-in-place operation on integer or complex data**

```c
IppStatus ippiSub_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);
```

Supported values for `mod`:

- `8u_C1RSfs`
- `16u_C1RSfs`
- `16s_C1RSfs`
- `8u_C3RSfs`
- `16u_C3RSfs`
- `16s_C3RSfs`
- `8u_AC4RSfs`
- `16u_AC4RSfs`
- `16s_AC4RSfs`
- `8u_C4RSfs`
- `16u_C4RSfs`
- `16s_C4RSfs`

**Case 2: Not-in-place operation on floating-point or complex data**

```c
IppStatus ippiSub_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);
```

Supported values for `mod`:

- `32f_C1R`
- `32f_C3R`
- `32f_AC4R`
- `32f_C4R`

**Case 3: In-place operation on integer or complex data**

```c
IppStatus ippiSub_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, int scaleFactor);
```

Supported values for `mod`:

- `8u_C1IRSfs`
- `16u_C1IRSfs`
- `16s_C1IRSfs`
- `8u_C3IRSfs`
- `16u_C3IRSfs`
- `16s_C3IRSfs`
- `8u_AC4IRSfs`
- `16u_AC4IRSfs`
- `16s_AC4IRSfs`
- `8u_C4IRSfs`
- `16u_C4IRSfs`
- `16s_C4IRSfs`
Case 4: In-place operation on floating-point or complex data

IppStatus ippiSub_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

32f_C1IR
32f_C3IR
32f_AC4IR
32f_C4IR

Case 5: Not-in-place operation on integer data with platform-aware functions

IppStatus ippiSub_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, const Ipp<datatype>* pSrc2, IppSizeL src2Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1RSfs_L  16u_C1RSfs_L  16s_C1RSfs_L
8u_C3RSfs_L  16u_C3RSfs_L  16s_C3RSfs_L
8u_AC4RSfs_L 16u_AC4RSfs_L  16s_AC4RSfs_L
8u_C4RSfs_L  16u_C4RSfs_L  16s_C4RSfs_L

Case 6: Not-in-place operation on floating-point data with platform-aware functions

IppStatus ippiSub_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, const Ipp<datatype>* pSrc2, IppSizeL src2Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppiSizeL roiSize);

Supported values for mod:

32f_C1R_L
32f_C3R_L
32f_C4R_L
32f_AC4R_L

Case 7: In-place operation on integer data with platform-aware functions

IppStatus ippiSub_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs_L  16u_C1IRSfs_L  16s_C1IRSfs_L
8u_C3IRSfs_L  16u_C3IRSfs_L  16s_C3IRSfs_L
8u_AC4IRSfs_L 16u_AC4IRSfs_L  16s_AC4IRSfs_L
Case 8: In-place operation on floating-point data with platform-aware functions
IppStatus ippiSub_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppiSizeL roiSize);

Supported values for mod:

32f_C1IR_L
32f_C3IR_L
32f_AC4IR_L
32f_C4IR_L

Case 9: Not-in-place operation on integer data with threading layer (TL) functions
IppStatus ippiSub_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, const Ipp<datatype>* pSrc2, IppSizeL src2Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1RSfs_LT
8u_C3RSfs_LT
8u_AC4RSfs_LT
8u_C4RSfs_LT

Case 10: Not-in-place operation on floating-point data with TL functions
IppStatus ippiSub_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, const Ipp<datatype>* pSrc2, IppSizeL src2Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppiSizeL roiSize);

Supported values for mod:

32f_C1R_LT
32f_C3R_LT
32f_C4R_LT
32f_AC4R_LT

Case 11: In-place operation on integer data with TL functions
IppStatus ippiSub_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs_LT
8u_C3IRSfs_LT
8u_C4IRSfs_LT
8u_C3IRSfs_LT
8u_C4IRSfs_LT
16u_C4IRSfs_LT
16u_C3IRSfs_LT
16s_C4IRSfs_LT
16s_C3IRSfs_LT
Case 12: In-place operation on floating-point data with TL functions

IppStatus ippiSub_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize);

Supported values for mod:

- 32f_C1IR_LT
- 32f_C3IR_LT
- 32f_AC4IR_LT
- 32f_C4IR_LT

Include Files

ippi.h

Flavors with the _LT suffix: ippi_tl.h
Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Flavors declared inippi.h:
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared inippi_tl.h:

Parameters

pSrc, pSrc1, pSrc2
srcStep, src1Step, src2Step
pDst
dstStep
pSrcDst
srcDstStep
roiSize
scaleFactor

Pointers to the source images ROI.
Distances in bytes between starts of consecutive lines in the source images.
Pointer to the destination image ROI.
Distance in bytes between starts of consecutive lines in the destination image.
Pointer to the source and destination image ROI for the in-place operation.
Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.
Size of the source and destination ROI in pixels.
Scale factor (see Integer Result Scaling).

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function subtracts pixel values of the source buffer \textit{pSrc1} from the corresponding pixel values of the buffer \textit{pSrc2} and places the result in the destination buffer \textit{pDst}. For in-place operations, the values in \textit{pSrc} are subtracted from the values in \textit{pSrcDst} and the results are placed into \textit{pSrcDst}. For complex data, the function processes both real and imaginary parts of pixel values.

\textbf{NOTE}
Step values must be positive for functions that operate on complex data.

In case of operations on integer data, the resulting values are scaled by \textit{scaleFactor}.

Note that the functions with \textit{AC4} descriptor do not process alpha channels.

\textbf{Return Values}

\begin{itemize}
  \item \texttt{ippStsNoErr} Indicates no error. Any other value indicates an error or a warning.
  \item \texttt{ippStsNullPtrErr} Indicates an error condition if one of the specified pointers is NULL.
  \item \texttt{ippStsSizeErr} Indicates an error condition if \textit{roiSize} has a field with zero or negative value.
  \item \texttt{ippStsStepErr} Indicates an error condition if any of the specified buffer step values is zero or negative for functions that operate on complex data.
\end{itemize}

\textbf{SubC}
\textit{Subtracts a constant from pixel values of an image.}

\textbf{Syntax}

\textbf{Case 1: Not-in-place operation on one-channel integer or complex data}

\begin{verbatim}
IppStatus ippiSubC_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype> value, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);
\end{verbatim}

\textbf{Supported values for} \texttt{mod}:

\begin{itemize}
  \item 8u\_C1RSfs
  \item 16u\_C1RSfs
  \item 16s\_C1RSfs
\end{itemize}

\textbf{Case 2: Not-in-place operation on multi-channel integer or complex data}

\begin{verbatim}
IppStatus ippiSubC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);
\end{verbatim}

\textbf{Supported values for} \texttt{mod}:

\begin{itemize}
  \item 8u\_C3RSfs
  \item 16u\_C3RSfs
  \item 16s\_C3RSfs
\end{itemize}
IppStatus ippiSubC_<mod>({const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[4], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor});

Supported values for mod:

8u_C4RSfs  16u_C4RSfs  16s_C4RSfs

IppStatus ippiSubC_<mod>({const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor});

Supported values for mod:

8u_AC4RSfs  16u_AC4RSfs  16s_AC4RSfs

Case 3: Not-in-place operation on one-channel floating-point or complex data
IppStatus ippiSubC_32f_C1R(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype> value, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Case 4: Not-in-place operation on multi-channel floating-point or complex data
IppStatus ippiSubC_32f_C3R(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiSubC_32f_C4R(const Ipp32f* pSrc, int srcStep, const Ipp32f value[4], Ipp32f* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiSubC_<mod>({const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize});

Supported values for mod:

32f_AC4R

Case 5: In-place operation on one-channel integer or complex data
IppStatus ippiSubC_<mod>({Ipp<datatype> value, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, int scaleFactor});

Supported values for mod:

8u_C1IRSfs  16u_C1IRSfs  16s_C1IRSfs

Case 6: In-place operation on multi-channel integer or complex data
IppStatus ippiSubC_<mod>({const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, int scaleFactor});

Supported values for mod:

8u_C3IRSfs  16u_C3IRSfs  16s_C3IRSfs
8u_AC4IRSfs  16u_AC4IRSfs  16s_AC4IRSfs
IppStatus ippiSubC_<mod>(const Ipp<datatype> value[4], Ipp<datatype>* pSrcDst, int srcDstStep, IppSize roiSize, int scaleFactor);

Supported values for mod:

8u_C4IRSfs  16u_C4IRSfs  16s_C4IRSfs

**Case 7: In-place operation on one-channel floating-point or complex data**

IppStatus ippiSubC_32f_C1IR(Ipp<datatype> value, Ipp<datatype>* pSrcDst, int srcDstStep, IppSize roiSize);

**Case 8: In-place operation on multi-channel floating-point or complex data:**

IppStatus ippiSubC_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, int srcDstStep, IppSize roiSize);

Supported values for mod:

32f_C3IR
32f_AC4IR

IppStatus ippiSubC_32f_C4IR(const Ipp32f value[4], Ipp32f* pSrcDst, int srcDstStep, IppSize roiSize);

**Case 9: Not-in-place operation on one-channel integer data with platform-aware functions**

IppStatus ippiSubC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype> value, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1RSfs_L  16u_C1RSfs_L  16s_C1RSfs_L

**Case 10: Not-in-place operation on multi-channel integer data with platform-aware functions**

IppStatus ippiSubC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, const Ipp<datatype> value[3], Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C3RSfs_L  16u_C3RSfs_L  16s_C3RSfs_L

8u_AC4RSfs_L  16u_AC4RSfs_L  16s_AC4RSfs_L

IppStatus ippiSubC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, const Ipp<datatype> value[4], Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C4RSfs_L  16u_C4RSfs_L  16s_C4RSfs_L

**Case 11: Not-in-place operation on one-channel floating point data with platform-aware functions**

IppStatus ippiSubC_32f_C1R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f value, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize);
Case 12: Not-in-place operation on multi-channel floating point data with platform-aware functions

IppStatus ippiSubC_<mod>(const Ipp32f* pSrc, IppSizeL srcStep, const Ipp32f value[3], Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize);

Supported values for mod:

32f_C3R_L
32f_AC4R_L

IppStatus ippiSubC_32f_C4R_L(const Ipp32f* pSrc, IppSizeL srcStep, const Ipp32f value[4], Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize);

Case 13: In-place operation on one-channel integer data with platform-aware functions

IppStatus ippiSubC_<mod>(Ipp<datatype> value, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs_L 16u_C1IRSfs_L 16s_C1IRSfs_L

Case 14: In-place operation on multi-channel integer data with platform-aware functions

IppStatus ippiSubC_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C3IRSfs_L 16u_C3IRSfs_L 16s_C3IRSfs_L
8u_AC4IRSfs_L 16u_AC4IRSfs_L 16s_AC4IRSfs_L

IppStatus ippiSubC_<mod>(const Ipp<datatype> value[4], Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C4IRSfs_L 16u_C4IRSfs_L 16s_C4IRSfs_L

Case 15: In-place operation on one-channel floating point data with platform-aware functions

IppStatus ippiSubC_32f_C1IR_L(Ipp32f value, Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);

Case 16: In-place operation on multi-channel integer data with platform-aware functions

IppStatus ippiSubC_<mod>(const Ipp32f value[3], Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);

Supported values for mod:

32f_C3IR_L
32f_AC4IR_L

IppStatus ippiSubC_32f_C4IR_L(const Ipp32f value[4], Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);
Case 17: Not-in-place operation on one-channel integer data with threading layer (TL) functions

IppStatus ippiSubC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype> value, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1RSfs_LT  16u_C1RSfs_LT  16s_C1RSfs_LT

Case 18: Not-in-place operation on multi-channel integer data with TL functions

IppStatus ippiSubC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, const Ipp<datatype> value[3], Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C3RSfs_LT  16u_C3RSfs_LT  16s_C3RSfs_LT

8u_AC4RSfs_LT  16u_AC4RSfs_LT  16s_AC4RSfs_LT

IppStatus ippiSubC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, const Ipp<datatype> value[4], Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C4RSfs_LT  16u_C4RSfs_LT  16s_C4RSfs_LT

Case 19: Not-in-place operation on one-channel floating point data with TL functions

IppStatus ippiSubC_32f_C1R_LT(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f value, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize);

Case 20: Not-in-place operation on multi-channel floating point data with TL functions

IppStatus ippiSubC_<mod>(const Ipp32f* pSrc, IppSizeL srcStep, const Ipp32f value[3], Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize);

Supported values for mod:

32f_C3R_LT

32f_AC4R_LT

IppStatus ippiSubC_32f_C4R_LT(const Ipp32f* pSrc, IppSizeL srcStep, const Ipp32f value[4], Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize);

Case 21: In-place operation on one-channel integer data with TL functions

IppStatus ippiSubC_<mod>(Ipp<datatype> value, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs_LT  16u_C1IRSfs_LT  16s_C1IRSfs_LT
Case 22: In-place operation on multi-channel integer data with TL functions

IppStatus ippiSubC_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C3IRSfs_LT  16u_C3IRSfs_LT  16s_C3IRSfs_LT
8u_AC4IRSfs_LT  16u_AC4IRSfs_LT  16s_AC4IRSfs_LT

IppStatus ippiSubC_<mod>(const Ipp<datatype> value[4], Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C4IRSfs_LT  16u_C4IRSfs_LT  16s_C4IRSfs_LT

Case 23: In-place operation on one-channel floating point data with TL functions

IppStatus ippiSubC_32f_C1IR_LT(Ipp32f value, Ipp32f* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize);

Case 24: In-place operation on multi-channel integer data with TL functions

IppStatus ippiSubC_<mod>(const Ipp32f value[3], Ipp32f* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize);

Supported values for mod:

32f_C3IR_LT
32f_AC4IR_LT

IppStatus ippiSubC_32f_C4IR_LT(const Ipp32f value[4], Ipp32f* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize);

Include Files

ippi.h

Flavors with the _LT suffix: ippi_tl.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Flavors declared in ippi.h:

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:


Parameters

pSrc

Pointer to the source image ROI.

dstStep

Distance in bytes between starts of consecutive lines in the source image.
The constant value to subtract from each pixel value in a source image (constant vector in case of multi-channel images).

Pointer to the destination image ROI.

Distance in bytes between starts of consecutive lines in the destination image.

Pointer to the source and destination image ROI for the in-place operation.

Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.

Size of the source and destination ROI in pixels.

Scale factor (see Integer Result Scaling).

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function changes image intensity by subtracting the constant value from pixel values of an image buffer. For multi-channel images, the components of a constant vector value are subtracted from pixel channel values. For complex data, the function processes both real and imaginary parts of pixel values.

**NOTE**

Step values must be positive for functions that operate on complex data.

In case of operations on integer data, the resulting values are scaled by scaleFactor.

Note that the functions with the AC4 descriptor do not process alpha channels.

Return Values

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error condition if one of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error condition if roiSize has a field with zero or negative value.
- ippStsStepErr: Indicates an error condition if any of the specified buffer step values is zero or negative for functions that operate on complex data.

Div

Divides pixel values of an image by pixel values of another image.
Syntax

Case 1: Not-in-place operation on integer or complex data

IppStatus ippiDiv_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp<datatype>* pDst, int dstStep, IppSize roiSize, int scaleFactor);

Supported values for mod:

<table>
<thead>
<tr>
<th>8u_C1RSfs</th>
<th>16u_C1RSfs</th>
<th>16s_C1RSfs</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_C3RSfs</td>
<td>16u_C3RSfs</td>
<td>16s_C3RSfs</td>
</tr>
<tr>
<td>8u_AC4RSfs</td>
<td>16u_AC4RSfs</td>
<td>16s_AC4RSfs</td>
</tr>
<tr>
<td>8u_C4RSfs</td>
<td>16u_C4RSfs</td>
<td>16s_C4RSfs</td>
</tr>
</tbody>
</table>

Case 2: Not-in-place operation on floating-point or complex data

IppStatus ippiDiv_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp<datatype>* pDst, int dstStep, IppSize roiSize);

Supported values for mod:

<table>
<thead>
<tr>
<th>32f_C1R</th>
<th>32f_C3R</th>
<th>32f_AC4R</th>
<th>32f_C4R</th>
</tr>
</thead>
</table>

Case 3: In-place operation on integer or complex data

IppStatus ippiDiv_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pSrcDst, int dstStep, IppSize roiSize, int scaleFactor);

Supported values for mod:

<table>
<thead>
<tr>
<th>8u_C1IRSfs</th>
<th>16u_C1IRSfs</th>
<th>16s_C1IRSfs</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_C3IRSfs</td>
<td>16u_C3IRSfs</td>
<td>16s_C3IRSfs</td>
</tr>
<tr>
<td>8u_AC4IRSfs</td>
<td>16u_AC4IRSfs</td>
<td>16s_AC4IRSfs</td>
</tr>
<tr>
<td>8u_C4IRSfs</td>
<td>16u_C4IRSfs</td>
<td>16s_C4IRSfs</td>
</tr>
</tbody>
</table>

Case 4: In-place operation on floating-point or complex data

IppStatus ippiDiv_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pSrcDst, int dstStep, IppSize roiSize);

Supported values for mod:

<table>
<thead>
<tr>
<th>32f_C1IR</th>
<th>32f_C3IR</th>
<th>32f_AC4IR</th>
</tr>
</thead>
</table>

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Case 5: Not-in-place operation on integer data with platform-aware functions

IppStatus ippiDiv_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, const Ipp<datatype>* pSrc2, IppSizeL src2Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

- 8u_C1RSfs_L
- 16u_C1RSfs_L
- 16s_C1RSfs_L
- 8u_C3RSfs_L
- 16u_C3RSfs_L
- 16s_C3RSfs_L
- 8u_AC4RSfs_L
- 16u_AC4RSfs_L
- 16s_AC4RSfs_L
- 8u_C4RSfs_L
- 16u_C4RSfs_L
- 16s_C4RSfs_L

Case 6: Not-in-place operation on floating-point data with platform-aware functions

IppStatus ippiDiv_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, const Ipp<datatype>* pSrc2, IppSizeL src2Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppiSizeL roiSize);

Supported values for mod:

- 32f_C1R_L
- 32f_C3R_L
- 32f_AC4R_L
- 32f_C4R_L

Case 7: In-place operation on integer data with platform-aware functions

IppStatus ippiDiv_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

- 8u_C1IRSfs_L
- 16u_C1IRSfs_L
- 16s_C1IRSfs_L
- 8u_C3IRSfs_L
- 16u_C3IRSfs_L
- 16s_C3IRSfs_L
- 8u_AC4IRSfs_L
- 16u_AC4IRSfs_L
- 16s_AC4IRSfs_L
- 8u_C4IRSfs_L
- 16u_C4IRSfs_L
- 16s_C4IRSfs_L

Case 8: In-place operation on floating-point data with platform-aware functions

IppStatus ippiDiv_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize);

Supported values for mod:

- 32f_C1IR_L
- 32f_C3IR_L
Case 9: Not-in-place operation on integer data with threading layer (TL) functions

IppStatus ippiDiv_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, const Ipp<datatype>* pSrc2, IppSizeL src2Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

- 8u_C1RSfs_LT
- 8u_C3RSfs_LT
- 8u_AC4RSfs_LT
- 8u_C4RSfs_LT
- 16u_C1RSfs_LT
- 16u_C3RSfs_LT
- 16u_AC4RSfs_LT
- 16u_C4RSfs_LT
- 16s_C1RSfs_LT
- 16s_C3RSfs_LT
- 16s_AC4RSfs_LT
- 16s_C4RSfs_LT

Case 10: Not-in-place operation on floating-point data with TL functions

IppStatus ippiDiv_<mod>(const Ipp<datatype>* pSrc1, IppSizeL src1Step, const Ipp<datatype>* pSrc2, IppSizeL src2Step, Ipp<datatype>* pDst, IppSizeL dstStep, IppiSizeL roiSize);

Supported values for mod:

- 32f_C1R_LT
- 32f_C3R_LT
- 32f_C4R_LT
- 32f_AC4R_LT
- 32f_C1R_LT
- 32f_C3R_LT
- 32f_C4R_LT
- 32f_AC4R_LT

Case 11: In-place operation on integer data with TL functions

IppStatus ippiDiv_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

- 8u_C1IRSfs_LT
- 8u_C3IRSfs_LT
- 8u_AC4IRSfs_LT
- 8u_C4IRSfs_LT
- 16u_C1IRSfs_LT
- 16u_C3IRSfs_LT
- 16u_AC4IRSfs_LT
- 16u_C4IRSfs_LT
- 16s_C1IRSfs_LT
- 16s_C3IRSfs_LT
- 16s_AC4IRSfs_LT
- 16s_C4IRSfs_LT

Case 12: In-place operation on floating-point data with TL functions

IppStatus ippiDiv_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize);

Supported values for mod:

- 32f_C1IR_LT
Include Files
ippi.h
Flavors with the _LT suffix:ippi_tl.h
Flavors with the _L suffix:ippi_l.h

Domain Dependencies
Flavors declared in ippi.h:
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
Flavors declared in ippi_tl.h:

Parameters
pSrc, pSrc1, pSrc2
srcStep, src1Step, src2Step
pDst
dstStep
pSrcDst
srcDstStep
roiSize
scaleFactor

Pointers to the source images ROI.
Distances in bytes between starts of consecutive lines in the source images.
Pointer to the destination image ROI.
Distance in bytes between starts of consecutive lines in the destination image.
Pointer to the source and destination image ROI for the in-place operation.
Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.
Size of the source and destination ROI in pixels.
Scale factor (see Integer Result Scaling).

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function divides pixel values of the source buffer pSrc2 by the corresponding pixel values of the buffer pSrc1 and places the result in a destination buffer pDst. For in-place operations, the values in pSrcDst are divided by the values in pSrc and placed into pSrcDst. For complex data, the function processes both real and imaginary parts of pixel values. In case of operations on integer data, the resulting values are scaled by scaleFactor and rounded (not truncated). When the function encounters a zero divisor value, the execution is not interrupted. The function returns the warning message and corresponding result value (see appendix A “Handling of Special Cases” for more information).

Note that the functions with the AC4 descriptor do not process alpha channels.
Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr Indicates an error condition if one of the specified pointers is NULL.

ippStsSizeErr Indicates an error condition if roiSize has a field with zero or negative value.

ippStsStepErr Indicates an error condition if any of the specified buffer step values is zero or negative.

ippStsDivByZero Indicates a warning that a divisor value is zero. The function execution is continued.

Example

The code example below illustrates how the function ippiDiv can be used.

```c
IppStatus div32f( void ) {
    Ipp32f a[4*3], b[4*3];
    IppiSize roi = {2,2};
    int i;
    for( i=0; i<4*3; ++i ) a[i] = b[i] = (float)i;
    return ippiDiv_32f_C1IR( a, 4*sizeof(Ipp32f), b,
                              4*sizeof(Ipp32f), roi );
}
```

The destination image b contains

-1.#IND  +1.000  +2.000  +3.000  +1.000  +1.000  +6.000  +7.000  +8.000  +9.000  +10.00  +11.00

Console output:

-- warning in div32f:
(6) Zero value(s) of divisor in the function Div

Div_Round

Divides pixel values of an image by pixel values of another image with different rounding modes.

Syntax

Case 1: Not-in-place operation on integer data

```c
IppStatus ippiDiv_Round_<mod>( const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppRoundMode rndMode, int scaleFactor);
```

Supported values for mod:

- 8u_C1RSfs
- 16u_C1RSfs
- 16s_C1RSfs
- 8u_C3RSfs
- 16u_C3RSfs
- 16s_C3RSfs
Case 2: In-place operation on integer data

IppStatus ippiDiv_Round_<mod>(const Ipp\<datatype\>* pSrc, int srcStep, Ipp\<datatype\>* pSrcDst, int srcDstStep, IppiSize roiSize, IppRoundMode rndMode, int scaleFactor);

Supported values for mod:

- 8u_C1IRSfs
- 16u_C1IRSfs
- 16s_C1IRSfs
- 8u_C3IRSfs
- 16u_C3IRSfs
- 16s_C3IRSfs
- 8u_AC4IRSfs
- 16u_AC4IRSfs
- 16s_AC4IRSfs
- 8u_C4IRSfs
- 16u_C4IRSfs
- 16s_C4IRSfs

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- pSrc, pSrc1, pSrc2: Pointers to the source images ROI.
- srcStep, src1Step, src2Step: Distances in bytes between starts of consecutive lines in the source images.
- pDst: Pointer to the destination image ROI.
- dstStep: Distance in bytes between starts of consecutive lines in the destination image.
- pSrcDst: Pointer to the source and destination image ROI for the in-place operation.
- srcDstStep: Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.
- roiSize: Size of the source and destination ROI in pixels.
- roundMode: Rounding mode, the following values are possible:
  - ippRndZero: specifies that floating-point values are truncated toward zero,
  - ippRndNear: specifies that floating-point values are rounded to the nearest even integer when the fractional part equals 0.5; otherwise they are rounded to the nearest integer,
**ippRndFinancial** specifies that floating-point values are rounded down to the nearest integer when the fractional part is less than 0.5, or rounded up to the nearest integer if the fractional part is equal or greater than 0.5.

**scaleFactor**

Scale factor (see Integer Result Scaling).

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function divides pixel values of the source buffer `pSrc2` by the corresponding pixel values of the buffer `pSrc1` and places the result in a destination buffer `pDst`. For in-place operations, the values in `pSrcDst` are divided by the values in `pSrc` and placed into `pSrcDst`. The resulting values are scaled by `scaleFactor` and rounded using the rounding method specified by the parameter `roundMode`. When the function encounters a zero divisor value, the execution is not interrupted. The function returns the warning message and corresponding result value (see appendix A "Handling of Special Cases" for more information).

Note that the functions with the AC4 descriptor do not process alpha channelles.

**Return Values**

- **ippStsNoErr** Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr** Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr** Indicates an error condition if `roiSize` has a field with zero or negative value.
- **ippStsStepErr** Indicates an error condition if any of the specified buffer step values is zero or negative.
- **ippStsDivByZero** Indicates a warning that a divisor value is zero. The function execution is continued.
- **ippStsRoundModeNotSupported** Indicates an error condition if the `roundMode` has an illegal value.
- **Err**

**DivC**

Divides pixel values of an image by a constant.

**Syntax**

**Case 1: Not-in-place operation on one-channel integer or complex data**

```c
IppStatus ippiDivC_<mod>(const Ipp<datatype> * pSrc, int srcStep, Ipp<datatype> value, Ipp<datatype> * pDst, int dstStep, IppSize roiSize, int scaleFactor);
```

Supported values for `mod`:

- 8u_C1RSfs
- 16u_C1RSfs
- 16s_C1RSfs

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Case 2: Not-in-place operation on multi-channel integer or complex data

IppStatus ippiDivC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[mod]. Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C3RSfs 16u_C3RSfs 16s_C3RSfs 16s_AC4RSfs

IppStatus ippiDivC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[mod]. Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C4RSfs 16u_C4RSfs 16s_C4RSfs

IppStatus ippiDivC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[mod]. Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_AC4RSfs 16u_AC4RSfs

Case 3: Not-in-place operation on one-channel floating-point or complex data

IppStatus ippiDivC_32f_C1R(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype> value, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Case 4: Not-in-place operation on multi-channel floating-point or complex data

IppStatus ippiDivC_32f_C3R(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[mod]. Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

IppStatus ippiDivC_32f_C4R(const Ipp32f* pSrc, int srcStep, const Ipp32f value[mod]. Ipp32f* pDst, int dstStep, IppiSize roiSize);

IppStatus ippiDivC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[mod]. Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

32f_AC4R

IppStatus ippiDivC_32f_C4R(const Ipp32f* pSrc, int srcStep, const Ipp32f value[mod]. Ipp32f* pDst, int dstStep, IppiSize roiSize);

Case 5: In-place operation on one-channel integer or complex data

IppStatus ippiDivC_<mod>(Ipp<datatype> value, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs 16u_C1IRSfs 16s_C1IRSfs
Case 6: In-place operation on multi-channel integer or complex data
IppStatus ippiDivC_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C3IRSfs    16u_C3IRSfs    16s_C3IRSfs
8u_AC4IRSfs    16u_AC4IRSfs    16s_AC4IRSfs

IppStatus ippiDivC_<mod>(const Ipp<datatype> value[4], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C4IRSfs 16u_C4IRSfs 16s_C4IRSfs

Case 7: In-place operation on one-channel floating-point or complex data
IppStatus ippiDivC_<mod>(Ipp<datatype> value, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

32f_C1IR

Case 8: In-place operation on multi-channel floating-point or complex data
IppStatus ippiDivC_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

32f_C3IR
32f_AC4IR

IppStatus ippiDivC_32f_C4IR(const Ipp32f value[4], Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize);

Case 9: Not-in-place operation on one-channel integer data with platform-aware functions
IppStatus ippiDivC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype> value, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1RSfs_L 16u_C1RSfs_L 16s_C1RSfs_L

Case 10: Not-in-place operation on multi-channel integer data with platform-aware functions
IppStatus ippiDivC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, const Ipp<datatype> value[3], Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C3RSfs_L 16u_C3RSfs_L 16s_C3RSfs_L
IppStatus ippiDivC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, const Ipp<datatype> value[4], Ipp<datatype>* pDst, IppSizeL dstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C4RSfs_L  16u_C4RSfs_L  16s_C4RSfs_L

Case 11: Not-in-place operation on one-channel floating point data with platform-aware functions
IppStatus ippiDivC_32f_C1R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f value, Ipp32f* pDst, IppSizeL dstStep, IppiSizeL roiSize);

Case 12: Not-in-place operation on multi-channel floating point data with platform-aware functions
IppStatus ippiDivC_<mod>(const Ipp32f* pSrc, IppSizeL srcStep, const Ipp32f value[3], Ipp32f* pDst, IppSizeL dstStep, IppiSizeL roiSize);

Supported values for mod:

32f_C3R_L
32f_AC4R_L

IppStatus ippiDivC_32f_C4R_L(const Ipp32f* pSrc, IppSizeL srcStep, const Ipp32f value[4], Ipp32f* pDst, IppSizeL dstStep, IppiSizeL roiSize);

Case 13: In-place operation on one-channel integer data with platform-aware functions
IppStatus ippiDivC_<mod>(Ipp<datatype> value, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs_L  16u_C1IRSfs_L  16s_C1IRSfs_L

Case 14: In-place operation on multi-channel integer data with platform-aware functions
IppStatus ippiDivC_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C3IRSfs_L  16u_C3IRSfs_L  16s_C3IRSfs_L
8u_AC4IRSfs_L  16u_AC4IRSfs_L  16s_AC4IRSfs_L

IppStatus ippiDivC_<mod>(const Ipp<datatype> value[4], Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C4IRSfs_L  16u_C4IRSfs_L  16s_C4IRSfs_L
Case 15: In-place operation on one-channel floating point data with platform-aware functions

```c
IppStatus ippiDivC_32f_C1IR_L(Ipp32f value, Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);
```

Case 16: In-place operation on multi-channel integer data with platform-aware functions

```c
IppStatus ippiDivC_<mod>(const Ipp32f value[3], Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);
```

Supported values for `mod`:

- 32f_C3IR_L
- 32f_AC4IR_L

```c
IppStatus ippiDivC_32f_C4IR_L(const Ipp32f value[4], Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);
```

Case 17: Not-in-place operation on one-channel integer data with threading layer (TL) functions

```c
IppStatus ippiDivC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype> value, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);
```

Supported values for `mod`:

- 8u_C1RSfs_LT
- 16u_C1RSfs_LT
- 16s_C1RSfs_LT

Case 18: Not-in-place operation on multi-channel integer data with TL functions

```c
IppStatus ippiDivC_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, const Ipp<datatype> value[3], Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, int scaleFactor);
```

Supported values for `mod`:

- 8u_C3RSfs_LT
- 16u_C3RSfs_LT
- 16s_C3RSfs_LT
- 8u_AC4RSfs_LT
- 16u_AC4RSfs_LT
- 16s_AC4RSfs_LT

Case 19: Not-in-place operation on one-channel floating point data with TL functions

```c
IppStatus ippiDivC_32f_C1R_LT(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f value, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize);
```

Case 20: Not-in-place operation on multi-channel floating point data with TL functions

```c
IppStatus ippiDivC_<mod>(const Ipp32f* pSrc, IppSizeL srcStep, const Ipp32f value[3], Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize);
```

Supported values for `mod`:

- 32f_C3R_LT
32f_AC4R_LT

IppStatus ippiDivC_32f_C4R_LT(const Ipp32f* pSrc, IppSizeL srcStep, const Ipp32f value[4], Ipp32f* pDst, IppSizeL dstStep, IppiSizeL roiSize);

Case 21: In-place operation on one-channel integer data with TL functions

IppStatus ippiDivC_<mod>(Ipp<datatype> value, Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs_LT  16u_C1IRSfs_LT  16s_C1IRSfs_LT

Case 22: In-place operation on multi-channel integer data with TL functions

IppStatus ippiDivC_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C3IRSfs_LT  16u_C3IRSfs_LT  16s_C3IRSfs_LT
8u_AC4IRSfs_LT  16u_AC4IRSfs_LT  16s_AC4IRSfs_LT

IppStatus ippiDivC_<mod>(const Ipp<datatype> value[4], Ipp<datatype>* pSrcDst, IppSizeL srcDstStep, IppiSizeL roiSize, int scaleFactor);

Supported values for mod:

8u_C4IRSfs_LT  16u_C4IRSfs_LT  16s_C4IRSfs_LT

Case 23: In-place operation on one-channel floating point data with TL functions

IppStatus ippiDivC_32f_C1IR_LT(Ipp32f value, Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);

Case 24: In-place operation on multi-channel integer data with TL functions

IppStatus ippiDivC_<mod>(const Ipp32f value[3], Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);

Supported values for mod:

32f_C3IR_LT
32f_AC4IR_LT

IppStatus ippiDivC_32f_C4IR_LT(const Ipp32f value[4], Ipp32f* pSrcDst, IppSizeL srcDstStep, IppSizeL roiSize);

Include Files

ippi.h

Flavors with the __LT suffix: ippi_tl.h
Flavors with the __L suffix: ippi_l.h
Domain Dependencies
Flavors declared in ippi.h:
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
Flavors declared in ippi_tl.h:

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **value**: The constant value to divide each pixel value in a source buffer (constant vector in case of 3- or four-channel images).
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **pSrcDst**: Pointer to the source and destination image ROI for the in-place operation.
- **srcDstStep**: Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.
- **roiSize**: Size of the source and destination ROI in pixels.
- **scaleFactor**: Scale factor (see InInteger Result Scaling).

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function changes image intensity by dividing pixel values of an image buffer by the constant **value**. For multi-channel images, pixel channel values are divided by the components of a constant vector **value**. For complex data, the function processes both real and imaginary parts of pixel values. In case of operations on integer data, the resulting values are scaled by **scaleFactor** and rounded (not truncated).
When the divisor value is zero, the function execution is aborted and the ippStsDivByZeroErr error status is set. Note that in the alpha channel case (**AC4**), the alpha channels are not processed.

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if **roiSize** has a field with zero or negative value.
- **ippStsStepErr**: Indicates an error condition if **srcStep**, **dstStep**, or **srcDstStep** has a zero or negative value.
- **ippStsDivByZeroErr**: Indicates an error condition if the divisor value is zero.
Abs

Computes absolute pixel values of a source image and places them into the destination image.

Case 1: Not-in-place operation

IppStatus ippiAbs_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

16s_C1R  32f_C1R
16s_C3R  32f_C3R
16s_C4R  32f_C4R
32f_AC4R

IppStatus ippiAbs_16s_AC4R(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Case 2: In-place operation

IppStatus ippiAbs_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

16s_C1IR  32f_C1IR
16s_C3IR  32f_C3IR
16s_C4IR  32f_C4IR
16s_AC4IR  32f_AC4IR

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc
srcStep
pDst
dstStep
pSrcDst

Pointer to the source image ROI.
Distance in bytes between starts of consecutive lines in the source image.
Pointer to the destination image ROI.
Distance in bytes between starts of consecutive lines in the destination image.
Pointer to the source and destination image ROI for the in-place operation.
srcDstStep
Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.

roiSize
Size of the source and destination ROI in pixels.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function takes the absolute value of each channel in each pixel of the source image ROI and places the result into a destination image ROI. It operates on signed data only. Note that the functions with the AC4 descriptor do not process alpha channels.

Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr
Indicates an error condition if one of the specified pointers is NULL.

ippStsSizeErr
Indicates an error condition if roiSize has a field with zero or negative value.

AbsDiff
Calculates absolute difference between two images.

Syntax

IppStatus ippiAbsDiff_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

  8u_C1R   16u_C1R   32f_C1R
  8u_C3R

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc1
Pointer to the first source image.

csrcStep
Distance in bytes between starts of consecutive lines in the first source image.

pSrc2
Pointer to second source image.

csrc2Step
Distance in bytes between starts of consecutive lines in the second source image.
AbsDiffC

Calculates absolute difference between image and scalar value.

Syntax

IppStatus ippiAbsDiffC_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int value);

Supported values for mod:

8u_C1R  16u_C1R

IppStatus ippiAbsDiffC_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, Ipp32f value);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc Pointer to the source image.

pDst Pointer to the destination image.

dstStep Distance in bytes between starts of consecutive lines in the destination image.

roiSize Size of the image ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function calculates the absolute pixel-wise difference between two images by the formula:

\[ pDst(x,y) = \text{abs}(pSrc1(x,y) - pSrc2(x,y)) \].

Return Values

ippStsNoErr Indicates no error.

ippStsNullPtrErr Indicates an error condition if one of the specified pointers is NULL.

ippStsSizeErr Indicates an error condition if roiSize has a field with zero or negative value.

ippStsStepErr Indicates an error when src1Step, src2Step or dstStep is less than roiSize.width * <pixelSize>.

ippStsNotEvenStepErr Indicates an error condition if one of step values for floating-point images cannot be divided by 4.
srcStep  
Distance in bytes between starts of consecutive lines in the source image.

pDst  
Pointer to the destination image.

dstStep  
Distance in bytes between starts of consecutive lines in the destination image.

roiSize  
Size of the image ROI in pixels.

value  
Scalar value used to decrement each element of the source image.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function calculates the absolute pixel-wise difference between the source image pSrc and the scalar value by the formula:

\[ pDst(x,y) = \text{abs}(pSrc(x,y) - \text{value}). \]

The function clips the value to the range \([0, 255]\) for the \(8u\) data type, and to the range \([0, 65535]\) for the \(16u\) data type.

Return Values

- **ippStsNoErr** Indicates no error.
- **ippStsNullPtrErr** Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr** Indicates an error condition if roiSize has a field with zero or negative value.
- **ippStsStepErr** Indicates an error when srcStep or dstStep is less than roiSize.width * <pixelSize>.
- **ippStsNotEvenStepErr** Indicates an error condition if one of step values for floating-point images cannot be divided by 4.

Sqr
Squares pixel values of an image and writes them into the destination image.

Syntax

**Case 1: Not-in-place operation on integer data**

```c
IppStatus ippiSqr_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);
```

Supported values for mod:

- 8u_C1RSfs 16u_C1RSfs 16s_C1RSfs
- 8u_C3RSfs 16u_C3RSfs 16s_C3RSfs
- 8u_C4RSfs 16u_C4RSfs 16s_C4RSfs
- 8u_AC4RSfs 16u_AC4RSfs 16s_AC4RSfs
Case 2: Not-in-place operation on floating-point data

IppStatus ippiSqr_<mod>(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

32f_C1R
32f_C3R
32f_C4R
32f_AC4R

Case 3: In-place operation on integer data

IppStatus ippiSqr_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs 16u_C1IRSfs 16s_C1IRSfs
8u_C3IRSfs 16u_C3IRSfs 16s_C3IRSfs
8u_C4IRSfs 16u_C4IRSfs 16s_C4IRSfs
8u_AC4IRSfs 16u_AC4IRSfs 16s_AC4IRSfs

Case 4: In-place operation on floating-point data

IppStatus ippiSqr_<mod>(Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

32f_C1IR
32f_C3IR
32f_C4IR
32f_AC4IR

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc
Pointer to the source image ROI.

csrcStep
Distance in bytes between starts of consecutive lines in the source image.
Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function squares pixel values of the source image ROI and writes them to the destination image ROI. The function flavors operating on integer data apply fixed scaling defined by scaleFactor to the internally computed values, and saturate the results before writing them to the destination image ROI.
Note that the functions with the AC4 descriptor do not process alpha channelss.

Return Values
ippStsNoErr Indicates an error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error condition if one of the specified pointers is NULL.
ippStsSizeErr Indicates an error condition if roiSize has a field with zero or negative value.

Sqrt
*Computes square roots of pixel values of a source image and writes them into the destination image.*

Syntax
Case 1: Not-in-place operation on integer data
IppStatus ippiSqrt_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);

Supported values for <mod>:
- 8u_C1RSfs
- 16u_C1RSfs
- 16s_C1RSfs
- 8u_C3RSfs
- 16u_C3RSfs
- 16s_C3RSfs
- 8u_AC4RSfs
- 16u_AC4RSfs
- 16s_AC4RSfs
Case 2: Not-in-place operation on floating-point data

IppStatus ippiSqrt_<mod>(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppisiSize roiSize);

Supported values for mod:

32f_C1R
32f_C3R
32f_AC4R

Case 3: In-place operation on integer data

IppStatus ippiSqrt_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppisiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs 16u_C1IRSfs 16s_C1IRSfs
8u_C3IRSfs 16u_C3IRSfs 16s_C3IRSfs
8u_AC4IRSfs 16u_AC4IRSfs 16s_AC4IRSfs

Case 4: In-place operation on floating-point data

IppStatus ippiSqrt_<mod>(Ipp32f* pSrcDst, int srcDstStep, IppisiSize roiSize);

Supported values for mod:

32f_C1IR
32f_C3IR
32f_C4IR
32f_AC4IR

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc, srcStep, pDst, dstStep

Pointer to the source image ROI.
Distance in bytes between starts of consecutive lines in the source image.
Pointer to the destination image ROI.
Distance in bytes between starts of consecutive lines in the destination image.
pSrcDst  
Pointer to the source and destination image ROI for the in-place operation.

srcDstStep  
Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.

roiSize  
Size of the source and destination ROI in pixels.

scaleFactor  
Scale factor (see Integer Result Scaling).

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP).

This function computes square roots of pixel values of the source image ROI and writes them into the destination image ROI. The function flavors operating on integer data apply fixed scaling defined by scaleFactor to the internally computed values, and saturate the results before writing them to the destination image ROI. If a source pixel value is negative, the function issues a warning and continues execution with the corresponding result value (see appendix A “Handling of Special Cases” for more information).

Note that the functions with the AC4 descriptor do not process alpha channels.

**Return Values**

- ippStsNoErr  
  Indicates no error. Any other value indicates an error or a warning.

- ippStsNullPtrErr  
  Indicates an error condition if one of the specified pointers is NULL.

- ippStsSizeErr  
  Indicates an error condition if roiSize has a field with zero or negative value.

- ippStsSqrtNegArg  
  Indicates a warning that a source pixel has a negative value.

**Ln**

*Computes the natural logarithm of pixel values in a source image and writes the results into the destination image.*

**Syntax**

**Case 1: Not-in-place operation on integer data**

```c
IppStatus ippiLn_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);
```

Supported values for mod:

- 8u_C1RSfs  
- 16u_C1RSfs  
- 16s_C1RSfs  
- 8u_C3RSfs  
- 16u_C3RSfs  
- 16s_C3RSfs
Case 2: Not-in-place operation on floating-point data
IppStatus ippiLn_<mod>(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

32f_C1R
32f_C3R

Case 3: In-place operation on integer data
IppStatus ippiLn_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, int scaleFactor);

Supported values for mod:

8u_C1IRSfs 16u_C1IRSfs 16s_C1IRSfs
8u_C3IRSfs 16u_C3IRSfs 16s_C3IRSfs

Case 4: In-place operation on floating-point data
IppStatus ippiLn_<mod>(Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

32f_C1IR
32f_C3IR

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc
Pointer to the source image ROI.

srcStep
Distance in bytes between starts of consecutive lines in the source image.

pDst
Pointer to the destination image ROI.

dstStep
Distance in bytes between starts of consecutive lines in the destination image.

pSrcDst
Pointer to the source and destination image ROI for the in-place operation.

dstStep
Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.

roiSize
Size of the source and destination ROI in pixels.

scaleFactor
Scale factor (see Integer Result Scaling).
Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function computes natural logarithms of pixel values of the source image ROI and writes the resultant values to the destination image ROI. The function flavors operating on integer data apply fixed scaling defined by scaleFactor to the internally computed values, and saturate the results before writing them to the destination image ROI.

If a source pixel value is zero or negative, the function issues a corresponding warning and continues execution with the corresponding result value (see appendix A "Handling of Special Cases" for more information).

When several inputs have zero or negative value, the status code returned by the function corresponds to the first encountered case as illustrated in the code example below.

Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error condition if one of the specified pointers is NULL.
ippStsSizeErr Indicates an error condition if roiSize has a field with zero or negative value.
ippStsStepErr Indicates an error condition if srcStep, dstStep, or srcDstStep has a zero or negative value.
ippStsLnZeroArg Indicates a warning that a source pixel has a zero value.
ippStsLnNegArg Indicates a warning that a source pixel has a negative value.

Example
The code example below shows how to use Ln function.

```c
IppStatus ln( void ) {
    Ipp32f img[8*8];
    IppiSize roi = { 8, 8 };  
    IppStatus st;
    ippiSet_32f_C1R( (float)IPP_E, img, 8*4, roi );
    img[0] = -0;
    img[1] = -1;
    st = ippiLn_32f_C1IR( img, 8*sizeof(Ipp32f), roi );
    printf( "%f %f %f\n", img[0], img[1], img[2] );
    return st;
}
```

Output values:

-1.#INF00 -1.#IND00 1.000000

Status value and message:

(7) Zero value(s) of argument in the Ln function

Exp
Computes the exponential of pixel values in a source image and writes the results into the destination image.
Syntax

Case 1: Not-in-place operation on integer data

IppStatus ippiExp_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int scaleFactor);

Supported values for `mod`:
- 8u_C1RSfs
- 16u_C1RSfs
- 16s_C1RSfs
- 8u_C3RSfs
- 16u_C3RSfs
- 16s_C3RSfs

Case 2: Not-in-place operation on floating-point data

IppStatus ippiExp_<mod>(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize);

Supported values for `mod`:
- 32f_C1R
- 32f_C3R

Case 3: In-place operation on integer data

IppStatus ippiExp_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, int scaleFactor);

Supported values for `mod`:
- 8u_C1IRSfs
- 16u_C1IRSfs
- 16s_C1IRSfs
- 8u_C3IRSfs
- 16u_C3IRSfs
- 16s_C3IRSfs

Case 4: In-place operation on floating-point data

IppStatus ippiExp_<mod>(Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for `mod`:
- 32f_C1IR
- 32f_C3IR

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- `pSrc`  
  Pointer to the source image ROI.
- `srcStep`  
  Distance in bytes between starts of consecutive lines in the source image.
**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function computes \(e\) to the power of pixel values of the source image ROI and writes the resultant values into the destination image ROI. The function flavors operating on integer data apply fixed scaling defined by `scaleFactor` to the internally computed values, and saturate the results before writing them to the destination image ROI.

When the overflow occurs, the resultant value is determined in accordance with the data type (see appendix A “Handling of Special Cases” for more information).

**Return Values**

- `ippStsNoErr` indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr` indicates an error condition if one of the specified pointers is NULL.
- `ippStsSizeErr` indicates an error condition if `roiSize` has a field with zero or negative value.
- `ippStsStepErr` indicates an error condition if `srcStep`, `dstStep`, or `srcDstStep` has a zero or negative value.

**DotProd**

*Computes the dot product of pixel values of two source images.*

**Syntax**

**Case 1: Operation on one-channel integer data**

```c
IppStatus ippiDotProd_<mod>(const Ipp<srcDatatype>* pSrc1, int src1Step, const Ipp<srcDatatype>* pSrc2, int src2Step, IppSize roiSize, Ipp64f* pDp);
```

Supported values for `mod`:

- `8u64f_C1R`
- `16u64f_C1R`
- `16s64f_C1R`
- `32u64f_C1R`
- `32s64f_C1R`
Case 2: Operation on three-channel integer data

IppStatus ippiDotProd_<mod>(const Ipp<srcDatatype>\* pSrc1, int src1Step, const Ipp<srcDatatype>\* pSrc2, int src2Step, IppiSize roiSize, Ipp64f pDp[3]);

Supported values for mod:

8u64f_C3R  16u64f_C3R  16s64f_C3R  32u64f_C3R  32s64f_C3R

Case 3: Operation on four-channel integer data

IppStatus ippiDotProd_<mod>(const Ipp<srcDatatype>\* pSrc1, int src1Step, const Ipp<srcDatatype>\* pSrc2, int src2Step, IppiSize roiSize, Ipp64f pDp[4]);

Supported values for mod:

8u64f_C4R  16u64f_C4R  16s64f_C4R  32u64f_C4R  32s64f_C4R

Case 4: Operation on floating-point data

IppStatus ippiDotProd_32f64f_C1R(const Ipp32f* pSrc1, int src1Step, const Ipp32f* pSrc2, int src2Step, IppiSize roiSize, Ipp64f* pDp, IppHintAlgorithm hint);

IppStatus ippiDotProd_32f64f_C3R(const Ipp32f* pSrc1, int src1Step, const Ipp32f* pSrc2, int src2Step, IppiSize roiSize, Ipp64f pDp[3], IppHintAlgorithm hint);

IppStatus ippiDotProd_32f64f_C4R(const Ipp32f* pSrc1, int src1Step, const Ipp32f* pSrc2, int src2Step, IppiSize roiSize, Ipp64f pDp[4], IppHintAlgorithm hint);

IppStatus ippiDotProd_32f64f_AC4R(const Ipp32f* pSrc1, int src1Step, const Ipp32f* pSrc2, int src2Step, IppiSize roiSize, Ipp64f pDp[3], IppHintAlgorithm hint);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc1, pSrc2  Pointer to the ROI in the source images.
src1Step, src2Step  Distance, in bytes, between the starting points of consecutive lines in the source images.
roiSize  Size of the source image ROI.
**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function computes the dot product of pixel values of two source images \( pSrc1 \) and \( pSrc2 \) using algorithm indicated by the hint argument (see Table “Hint Arguments for Image Moment Functions”) and stores the result in \( pDp \). In case of multi-channel images, the dot product is computed for each channel separately and stored in the array \( pDp \).

**Return Values**

- **ippStsNoErr**
  - Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**
  - Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**
  - Indicates an error condition if \( roiSize \) has a field with zero or negative value.
- **ippStsStepErr**
  - Indicates an error condition if one of the step values has zero or negative value.

**DotProdCol**

*Calculates the dot product of taps vector and columns of the specified set of rows.*

**Syntax**

```c
IppStatus ippiDotProdCol_32f_L2(const Ipp32f* const ppSrcRow[], const Ipp32f* pTaps, int tapsLen, Ipp32f* pDst, int width);

IppStatus ippiDotProdCol_64f_L2(const Ipp64f* const ppSrcRow[], const Ipp64f* pTaps, int tapsLen, Ipp64f* pDst, int width);
```

**Include Files**

`ippi.h`

**Domain Dependencies**

- Headers: `ippi.h`
- Libraries: `ippi.lib`, `ippvm.lib`, `ipps.lib`

**Parameters**

- **ppSrcRow**
  - Pointer to the set of rows.
- **pTaps**
  - Pointer to the taps vector.
- **tapsLen**
  - Length of taps vector, is equal to the number of rows.
- **pDst**
  - Pointer to the destination row.
- **width**
  - Width of the source and destination rows.
Description

This function calculates the dot product of taps vector $pTaps$ and columns of the specified set of the rows $ppSrcRow$. It is useful for external vertical filtering pipeline implementation.

Return Values

- ippStsNoErr: Indicates no error. Any other value indicates an error.
- ippStsNullPtrErr: Indicates an error condition if one of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error condition if $width$ is less than or equal to 0.

Logical Operations

Functions described in this section perform bitwise operations on pixel values. The operations include logical AND, NOT, inclusive OR, exclusive OR, and bit shifts.

And

*Performs a bitwise AND operation between corresponding pixels of two images.*

Syntax

**Case 1: Not-in-place operation**

IppStatus ippiAnd_<mod>(const Ipp<datatype>* $pSrc1$, int $src1Step$, const Ipp<datatype>* $pSrc2$, int $src2Step$, Ipp<datatype>* $pDst$, int $dstStep$, IppiSize $roiSize$);

Supported values for $mod$:

- 8u_C1R 16u_C1R 32s_C1R
- 8u_C3R 16u_C3R 32s_C3R
- 8u_C4R 16u_C4R 32s_C4R
- 8u_AC4R 16u_AC4R 32s_AC4R

**Case 2: In-place operation**

IppStatus ippiAnd_<mod>(const Ipp<datatype>* $pSrc$, int $srcStep$, Ipp<datatype>* $pSrcDst$, int $srcDstStep$, IppiSize $roiSize$);

Supported values for $mod$:

- 8u_C1R 16u_C1R 32s_C1R
- 8u_C3R 16u_C3R 32s_C3R
- 8u_C4R 16u_C4R 32s_C4R
- 8u_AC4R 16u_AC4R 32s_AC4R
Include Files
ippi.h

Domain Dependencies

Headers: ippicore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

\( pSrc, pSrc1, pSrc2 \)  
Pointers to the source images ROI.

\( srcStep, src1Step, src2Step \)  
Distances in bytes between starts of consecutive lines in the source images.

\( pDst \)  
Pointer to the destination image ROI.

\( dstStep \)  
Distance in bytes between starts of consecutive lines in the destination image.

\( pSrcDst \)  
Pointer to the source and destination image ROI for the in-place operation.

\( srcDstStep \)  
Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.

\( roiSize \)  
Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function performs a bitwise AND operation between the values of corresponding pixels of two source image ROIs, and writes the result into a destination image ROI.

Note that the functions with the AC4 descriptor do not process alpha channels.

Return Values

ippStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  
Indicates an error condition if one of the specified pointers is NULL.

ippStsSizeErr  
Indicates an error condition if \( roiSize \) has a field with zero or negative value.

ippStsStepErr  
Indicates an error condition if any of the specified buffer step values is zero or negative.

AndC
Performs a bitwise AND operation of each pixel with a constant.
Syntax

Case 1: Not-in-place operation on one-channel data
IppStatus ippiAndC_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype> value, Ipp<datatype>* pDst, int dstStep, IppSize roiSize);

Supported values for mod:

8u_C1R  16u_C1R  32s_C1R

Case 2: Not-in-place operation on multi-channel data
IppStatus ippiAndC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[3], Ipp<datatype>* pDst, int dstStep, IppSize roiSize);

Supported values for mod:

8u_C3R  16u_C3R  32s_C3R
8u_AC4R  16u_AC4R  32s_AC4R

IppStatus ippiAndC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[4], Ipp<datatype>* pDst, int dstStep, IppSize roiSize);

Supported values for mod:

8u_C4R  16u_C4R  32s_C4R

Case 3: In-place operation on one-channel data
IppStatus ippiAndC_<mod>(Ipp<datatype> value, Ipp<datatype>* pSrcDst, int srcDstStep, IppSize roiSize);

Supported values for mod:

8u_C1IR  16u_C1IR  32s_C1IR

Case 4: In-place operation on multi-channel data
IppStatus ippiAndC_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, int srcDstStep, IppSize roiSize);

Supported values for mod:

8u_C3IR  16u_C3IR  32s_C3IR
8u_AC4IR  16u_AC4IR  32s_AC4IR

IppStatus ippiAndC_<mod>(const Ipp<datatype> value[4], Ipp<datatype>* pSrcDst, int srcDstStep, IppSize roiSize);

Supported values for mod:

8u_C4IR  16u_C4IR  32s_C4IR

Include Files
ippi.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc  
Pointer to the source image ROI.

srcStep  
Distance in bytes between starts of consecutive lines in the source image.

value  
The constant value to perform the bitwise AND operation on each pixel of the source image ROI (constant vector in case of multi-channel images).

pDst  
Pointer to the destination image ROI.

dstStep  
Distance in bytes between starts of consecutive lines in the destination image.

pSrcDst  
Pointer to the source and destination image ROI for the in-place operation.

srcDstStep  
Distance in bytes between starts of consecutive lines in the source and destination image buffer for the in-place operation.

roiSize  
Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function performs a bitwise AND operation between each pixel value of a source image ROI and constant value.

Note that the functions with the AC4 descriptor do not process alpha channels.

Return Values

ippStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  
Indicates an error condition if one of the specified pointers is NULL.

ippStsSizeErr  
Indicates an error condition if roiSize has a field with a zero or negative value.

ippStsStepErr  
Indicates an error condition if srcStep, dstStep, or srcDstStep has a zero or negative value.

Or

Performs bitwise inclusive OR operation between pixels of two source buffers.
Syntax

Case 1: Not-in-place operation
IppStatus ippiOr_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp<datatype>* pDst, int dstStep, IppSize roiSize);

Supported values for mod:

- 8u_C1R
- 16u_C1R
- 32s_C1R
- 8u_C3R
- 16u_C3R
- 32s_C3R
- 8u_C4R
- 16u_C4R
- 32s_C4R
- 8u_AC4R
- 16u_AC4R
- 32s_AC4R

Case 2: In-place operation
IppStatus ippiOr_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pSrcDst, int srcDstStep, IppSize roiSize);

Supported values for mod:

- 8u_C1IR
- 16u_C1IR
- 32s_C1IR
- 8u_C3IR
- 16u_C3IR
- 32s_C3IR
- 8u_C4IR
- 16u_C4IR
- 32s_C4IR
- 8u_AC4IR
- 16u_AC4IR
- 32s_AC4IR

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- pSrc, pSrc1, pSrc2: Pointers to the source images ROI.
- srcStep, src1Step, src2Step: Distances in bytes between starts of consecutive lines in the source images.
- pDst: Pointer to the destination image ROI.
- dstStep: Distance in bytes between starts of consecutive lines in the destination image.
- pSrcDst: Pointer to the source and destination image ROI for the in-place operation.
- srcDstStep: Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.
- roiSize: Size of the source and destination ROI in pixels.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function performs a bitwise inclusive OR operation between the values of corresponding pixels of two source image ROIs, and writes the result into a destination image ROI. Note that the functions with the AC4 descriptor do not process alpha channels.

**Return Values**

- `ippStsNoErr`: Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr`: Indicates an error condition if one of the specified pointers is NULL.
- `ippStsSizeErr`: Indicates an error condition if `roiSize` has a field with zero or negative value.
- `ippStsStepErr`: Indicates an error condition if any of the specified buffer step values is zero or negative.

**Example**

The code example below show how to use the function `ippiOr_8u_C1R`.

```c
void func_or()
{
    IppiSize Src1ROI = {8,4};
    IppiSize Src2ROI = {8,4};
    IppiSize DstROI = {5,4};
    Ipp8u src1[8*4];
    Ipp8u src2[8*4];
    Ipp8u dst[8*4];

   ippiSet_8u_C1R(0,dest,8,Src1ROI);
    ippiSet_8u_C1R(5,src1,8,Src1ROI);
    ippiSet_8u_C1R(6,src2,8,Src2ROI);
    ippiOr_8u_C1R(src1,8,src2,8,dst,8,DstROI);
}
```

**Result:**

<table>
<thead>
<tr>
<th>src1</th>
<th>src2</th>
<th>dst</th>
</tr>
</thead>
<tbody>
<tr>
<td>05 05 05 05 05 05 05 05</td>
<td>06 06 06 06 06 06 06 06</td>
<td>07 07 07 07 07 00 00 00</td>
</tr>
<tr>
<td>05 05 05 05 05 05 05 05</td>
<td>06 06 06 06 06 06 06 06</td>
<td>07 07 07 07 07 00 00 00</td>
</tr>
<tr>
<td>05 05 05 05 05 05 05 05</td>
<td>06 06 06 06 06 06 06 06</td>
<td>07 07 07 07 07 00 00 00</td>
</tr>
<tr>
<td>05 05 05 05 05 05 05 05</td>
<td>06 06 06 06 06 06 06 06</td>
<td>07 07 07 07 07 00 00 00</td>
</tr>
</tbody>
</table>

**OrC**

Performs a bitwise inclusive OR operation between each pixel of a buffer and a constant.
Syntax

Case 1: Not-in-place operation on one-channel data
IppStatus ippiOrC_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype> value, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

8u_C1R  16u_C1R  32s_C1R

Case 2: Not-in-place operation on multi-channel data
IppStatus ippiOrC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

8u_C3R  16u_C3R  32s_C3R
8u_AC4R  16u_AC4R  32s_AC4R

IppStatus ippiOrC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[4], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

8u_C4R  16u_C4R  32s_C4R

Case 3: In-place operation on one-channel data
IppStatus ippiOrC_<mod>(Ipp<datatype> value, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u_C1IR  16u_C1IR  32s_C1IR

Case 4: In-place operation on multi-channel data
IppStatus ippiOrC_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u_C3IR  16u_C3IR  32s_C3IR
8u_AC4IR  16u_AC4IR  32s_AC4IR

IppStatus ippiOrC_<mod>(const Ipp<datatype> value[4], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u_C4IR  16u_C4IR  32s_C4IR

Include Files
ippi.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc  
Pointer to the source image ROI.

srcStep  
Distance in bytes between starts of consecutive lines in the source image.

value  
The constant value to perform the bitwise OR operation on each pixel of the source image (constant vector in case of multi-channel images).

pDst  
Pointer to the destination image ROI.

dstStep  
Distance in bytes between starts of consecutive lines in the destination image.

pSrcDst  
Pointer to the source and destination image ROI for the in-place operation.

srcDstStep  
Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.

roiSize  
Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function performs a bitwise inclusive OR operation between each pixel value of a source image ROI and constant value.

Note that the functions with the AC4 descriptor do not process alpha channels.

Return Values

ippStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  
Indicates an error condition if one of the specified pointers is NULL.

ippStsSizeErr  
Indicates an error condition if roiSize has a field with zero or negative value.

ippStsStepErr  
Indicates an error condition if srcStep, dstStep, or srcDstStep has a zero or negative value.

Xor

Performs bitwise exclusive OR operation between pixels of two source buffers.
Syntax

Case 1: Not-in-place operation

IppStatus ippiXor_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

- 8u_C1R
- 16u_C1R
- 32s_C1R
- 8u_C3R
- 16u_C3R
- 32s_C3R
- 8u_C4R
- 16u_C4R
- 32s_C4R
- 8u_AC4R
- 16u_AC4R
- 32s_AC4R

Case 2: In-place operation

IppStatus ippiXor_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

- 8u_C1IR
- 16u_C1IR
- 32s_C1IR
- 8u_C3IR
- 16u_C3IR
- 32s_C3IR
- 8u_C4IR
- 16u_C4IR
- 32s_C4IR
- 8u_AC4IR
- 16u_AC4IR
- 32s_AC4IR

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- pSrc, pSrc1, pSrc2: Pointers to the source images ROI.
- srcStep, src1Step, src2Step: Distances in bytes between starts of consecutive lines in the source images.
- pDst: Pointer to the destination image ROI.
- dstStep: Distance in bytes between starts of consecutive lines in the destination image.
- pSrcDst: Pointer to the source and destination image ROI for the in-place operation.
- srcDstStep: Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.
- roiSize: Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function performs a bitwise exclusive OR operation between the values of corresponding pixels of two source image ROIs, and writes the result into a destination image ROI.

Note that the functions with the AC4 descriptor do not process alpha channels.

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**
  Indicates an error condition if one of the specified pointers is NULL.

- **ippStsSizeErr**
  Indicates an error condition if roiSize has a field with zero or negative value.

- **ippStsStepErr**
  Indicates an error condition if any of the specified buffer step values is zero or negative.

**XorC**

*Performs a bitwise exclusive OR operation between each pixel of a buffer and a constant.*

**Syntax**

**Case 1: Not-in-place operation on one-channel data**

```c
IppStatus ippiXorC_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype> value, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);
```

Supported values for `<mod>`:

- 8u_C1R
- 16u_C1R
- 32s_C1R

**Case 2: Not-in-place operation on multi-channel data**

```c
IppStatus ippiXorC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);
```

Supported values for `<mod>`:

- 8u_C3R
- 16u_C3R
- 32s_C3R

- 8u_AC4R
- 16u_AC4R
- 32s_AC4R

```c
IppStatus ippiXorC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[4], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);
```

Supported values for `<mod>`:

- 8u_C4R
- 16u_C4R
- 32s_C4R
Case 3: In-place operation on one-channel data

IppStatus ippiXorC_<mod>(Ipp<datatype> value, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u_C1IR  16u_C1IR  32s_C1IR

Case 4: In-place operation on multi-channel data

IppStatus ippiXorC_<mod>(const Ipp<datatype> value[3], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u_C3IR  16u_C3IR  32s_C3IR
8u_AC4IR 16u_AC4IR 32s_AC4IR

IppStatus ippiXorC_<mod>(const Ipp<datatype> value[4], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u_C4IR  16u_C4IR  32s_C4IR

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc
Pointer to the source image ROI.

srcStep
Distance in bytes between starts of consecutive lines in the source image.

value
The constant value to perform the bitwise XOR operation on each pixel of the source image ROI (constant vector in case of multi-channel images).

pDst
Pointer to the destination image ROI.

dstStep
Distance in bytes between starts of consecutive lines in the destination image.

pSrcDst
Pointer to the source and destination image ROI for the in-place operation.

srcDstStep
Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.

roiSize
Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function performs a bitwise exclusive OR operation between each pixel value of a source image ROI and constant value.

Note that the functions with the AC4 descriptor do not process alpha channels.

**Return Values**

- **ippStsNoErr**
  - Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**
  - Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**
  - Indicates an error condition if roiSize has a field with zero or negative value.
- **ippStsStepErr**
  - Indicates an error condition if srcStep, dstStep, or srcDstStep has a zero or negative value.

**Not**

Performs a bitwise NOT operation on each pixel of a source buffer.

**Syntax**

**Case 1: Not-in-place operation**

```c
IppStatus ippiNot_<mod>(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
```

**Supported values for mod:**

- 8u_C1R
- 8u_C3R
- 8u_C4R
- 8u_AC4R

**Case 2: In-place operation**

```c
IppStatus ippiNot_<mod>(Ipp8u* pSrcDst, int srcDstStep, IppiSize roiSize);
```

**Supported values for mod:**

- 8u_C1IR
- 8u_C3IR
- 8u_C4IR
- 8u_AC4IR

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **pSrcDst**: Pointer to the source and destination image ROI for the in-place operation.
- **srcDstStep**: Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.
- **roiSize**: Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function performs a bitwise NOT operation on each pixel value of a source image ROI.
Note that the functions with the AC4 descriptor do not process alpha channels.

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if roiSize has a field with zero or negative value.
- **ippStsStepErr**: Indicates an error condition if srcStep, dstStep, or srcDstStep has a zero or negative value.

**RShiftC**

Shifts bits in pixel values to the right.

Case 1: Not-in-place operation on one-channel data

```c
IppStatus ippiRShiftC_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp32u value,
Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);
```

Supported values for *mod*:

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32s_C1R
Case 2: Not-in-place operation on multi-channel data

IppStatusippiRShiftC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp32u value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

<table>
<thead>
<tr>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_C3R</td>
<td></td>
</tr>
<tr>
<td>16u_C3R</td>
<td></td>
</tr>
<tr>
<td>16s_C3R</td>
<td></td>
</tr>
<tr>
<td>32s_C3R</td>
<td></td>
</tr>
</tbody>
</table>

IppStatusippiRShiftC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp32u value[4], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

<table>
<thead>
<tr>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_C4R</td>
<td></td>
</tr>
<tr>
<td>16u_C4R</td>
<td></td>
</tr>
<tr>
<td>16s_C4R</td>
<td></td>
</tr>
<tr>
<td>32s_C4R</td>
<td></td>
</tr>
</tbody>
</table>

IppStatusippiRShiftC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp32u value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

<table>
<thead>
<tr>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_AC4R</td>
<td></td>
</tr>
<tr>
<td>16u_AC4R</td>
<td></td>
</tr>
<tr>
<td>16s_AC4R</td>
<td></td>
</tr>
<tr>
<td>32s_AC4R</td>
<td></td>
</tr>
</tbody>
</table>

Case 3: In-place operation on one-channel data

IppStatusippiRShiftC_<mod>(Ipp32u value, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

<table>
<thead>
<tr>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_C1IR</td>
<td></td>
</tr>
<tr>
<td>16u_C1IR</td>
<td></td>
</tr>
<tr>
<td>16s_C1IR</td>
<td></td>
</tr>
<tr>
<td>32s_C1IR</td>
<td></td>
</tr>
</tbody>
</table>

Case 4: In-place operation on multi-channel data

IppStatusippiRShiftC_<mod>(const Ipp32u value[3], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

<table>
<thead>
<tr>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_C3IR</td>
<td></td>
</tr>
<tr>
<td>16u_C3IR</td>
<td></td>
</tr>
<tr>
<td>16s_C3IR</td>
<td></td>
</tr>
<tr>
<td>32s_C3IR</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_AC4IR</td>
<td></td>
</tr>
<tr>
<td>16u_AC4IR</td>
<td></td>
</tr>
<tr>
<td>16s_AC4IR</td>
<td></td>
</tr>
<tr>
<td>32s_AC4IR</td>
<td></td>
</tr>
</tbody>
</table>

IppStatusippiRShiftC_<mod>(const Ipp32u value[4], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

<table>
<thead>
<tr>
<th>Mod</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_C4IR</td>
<td></td>
</tr>
<tr>
<td>16u_C4IR</td>
<td></td>
</tr>
<tr>
<td>16s_C4IR</td>
<td></td>
</tr>
<tr>
<td>32s_C4IR</td>
<td></td>
</tr>
</tbody>
</table>

Include Files

ippi.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **value**: The number of bits to shift (constant vector in case of multi-channel images).
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **pSrcDst**: Pointer to the source and destination image ROI for the in-place operation.
- **srcDstStep**: Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.
- **roiSize**: Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function decreases the intensity of pixels in the source image ROI by shifting the bits in each pixel value by 
*value* bits to the right. The positions vacated after shifting the bits are filled with the sign bit. In case of multi-channel data, each color channel can have its own shift value. This operation is equivalent to dividing the pixel values by a constant power of 2.

Note that the functions with the **AC4** descriptor do not process alpha channels.

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if **roiSize** has a field with a zero or negative value.
- **ippStsStepErr**: Indicates an error condition if **srcStep**, **dstStep**, or **srcDstStep** has a zero or negative value.

**LShiftC**

*Shifts bits in pixel values to the left.*
Syntax

Case 1: Not-in-place operation on one-channel data

IppStatus ippiLShiftC_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp32u value, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

8u_C1R    16u_C1R    32s_C1R

Case 2: Not-in-place operation on multi-channel data

IppStatus ippiLShiftC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp32u value[3], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

8u_C3R    16u_C3R    32s_C3R    32s_AC4R
8u_AC4R    16u_AC4R

IppStatus ippiLShiftC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp32u value[4], Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

8u_C4R    16u_C4R    32s_C4R

Case 3: In-place operation on one-channel data

IppStatus ippiLShiftC_<mod>(Ipp32u value, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u_C1IR    16u_C1IR    32s_C1IR

Case 4: In-place operation on multi-channel data

IppStatus ippiLShiftC_<mod>(const Ipp32u value[3], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u_C3IR    16u_C3IR    32s_C3IR
8u_AC4IR    16u_AC4IR    32s_AC4IR

IppStatus ippiLShiftC_<mod>(const Ipp32u value[4], Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

8u_C4IR    16u_C4IR    32s_C4IR

Include Files

ippi.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **value**: The number of bits to shift (constant vector in case of multi-channel images).
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **pSrcDst**: Pointer to the source and destination image ROI for the in-place operation.
- **srcDstStep**: Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.
- **roiSize**: Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function changes the intensity of pixels in the source image ROI by shifting the bits in each pixel value by **value** bits to the left. In case of multi-channel data, each color channel can have its own shift value. The positions vacated after shifting the bits are filled with zeros. Values obtained as a result of left shift operations are not saturated. To get saturated values, use multiplication functions instead.

Note that the functions with the **AC4** descriptor do not process alpha channels.

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if **roiSize** has a field with zero or negative value.
- **ippStsStepErr**: Indicates an error condition if **srcStep**, **dstStep**, or **srcDstStep** has a zero or negative value.

Example

The code example below illustrates the use of left shift function.

```c
IppStatus lshift( void ) {
    Ipp8u img[8*8] = { 1, 0x7F, 0xFE ,
    IppiSize roi = { 8, 8 };
    IppStatus st = ippiLShiftC_8u_C1IR( 1, img, 8, roi );
    printf( "%02x %02x %02x\n", img[0], img[1], img[2] );
    return st;
}
```
Alpha Composition

The Intel IPP provides functions that composite two image buffers using either the opacity (alpha) channel in the images or provided alpha values.

These functions operate on image buffers with 8-bit or 16-bit data in RGB or RGBA format. In all compositing operations a resultant pixel in destination buffer $p_{Dst}$ is created by overlaying a pixel from the foreground image buffer $p_{Src1}$ over a pixel from the background image buffer $p_{Src2}$. The supported types of images combining by using alpha values are listed in the table below.

### Types of Image Composing Operations

<table>
<thead>
<tr>
<th>Type</th>
<th>Color Components</th>
<th>Output Pixel</th>
<th>Description in Imaging Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVER</td>
<td>$a_A A + (1- a_A) * a_B B$</td>
<td>$a_A + (1- a_A) * a_B$</td>
<td>$A$ occludes $B$</td>
</tr>
<tr>
<td>IN</td>
<td>$a_A A * a_B$</td>
<td>$a_A * a_B$</td>
<td>$A$ within $B$. $A$ acts as a matte for $B$. $A$ shows only where $B$ is visible.</td>
</tr>
<tr>
<td>OUT</td>
<td>$a_A A * (1- a_B)$</td>
<td>$a_A * (1- a_B)$</td>
<td>$A$ outside $B$. NOT-$B$ acts as a matte for $A$. $A$ shows only where $B$ is not visible.</td>
</tr>
<tr>
<td>ATOP</td>
<td>$a_A A * a_B + (1- a_A) * a_B B$</td>
<td>$a_A * a_B + (1- a_A) * a_B$</td>
<td>Combination of ($A$ IN $B$) and ($B$ OUT $A$). $B$ is both background and matte for $A$.</td>
</tr>
<tr>
<td>XOR</td>
<td>$a_A A * (1- a_B) + (1- a_A) * a_B B$</td>
<td>$a_A * (1- a_B) + (1- a_A) * a_B$</td>
<td>Combination of ($A$ OUT $B$) and ($B$ OUT $A$). $A$ and $B$ mutually exclude each other.</td>
</tr>
<tr>
<td>PLUS</td>
<td>$a_A A + a_B B$</td>
<td>$a_A + a_B$</td>
<td>Blend without precedence</td>
</tr>
</tbody>
</table>

In the formulas above, the input image buffers are denoted as $A$ and $B$ for simplicity. The Greek letter $\alpha$ with subscripts denotes the normalized (scaled) alpha value in the range 0 to 1. It is related to the integer alpha value $\text{alpha}$ as:

$$\alpha = \text{alpha} / \text{max\_val}$$

where \text{max\_val} is 255 for 8-bit or 65535 for 16-bit unsigned pixel data.

For the \text{ippiAlphaComp} function that operates on 4-channel RGBA buffers only, $a_A$ and $a_B$ are the normalized alpha values of the two input image buffers, respectively.

For the \text{ippiAlphaCompC} function, $a_A$ and $a_B$ are the normalized constant alpha values that are passed as parameters to the function.

Note that in formulas for computing the resultant color channel values, $A$ and $B$ stand for the pixel color components of the respective input image buffers.

To save a significant amount of computation for some of the alpha compositing operations, use functions \text{AlphaPremul}, \text{AlphaPremulC} for pre-multiplying color channel values by the alpha values. This reduces the number of multiplications required in the compositing operations, which is especially efficient for repeated compositing of an image.

The type of composition operation that is performed by the function \text{AlphaComp} and \text{AlphaCompC} is specified by the parameter $\alphaType$, the table below lists its possible values.
Possible Values of alphaType Parameter

<table>
<thead>
<tr>
<th>Operation types</th>
<th>Parameter Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>OVER</td>
<td>ippAlphaOver</td>
</tr>
<tr>
<td></td>
<td>ippAlphaOverPremul</td>
</tr>
<tr>
<td>IN</td>
<td>ippAlphaIn</td>
</tr>
<tr>
<td></td>
<td>ippAlphaInPremul</td>
</tr>
<tr>
<td>OUT</td>
<td>ippAlphaOut</td>
</tr>
<tr>
<td></td>
<td>ippAlphaOutPremul</td>
</tr>
<tr>
<td>ATOP</td>
<td>ippAlphaATop</td>
</tr>
<tr>
<td></td>
<td>ippAlphaATopPremul</td>
</tr>
<tr>
<td>XOR</td>
<td>ippAlphaXor</td>
</tr>
<tr>
<td></td>
<td>ippAlphaXorPremul</td>
</tr>
<tr>
<td>PLUS</td>
<td>ippAlphaPlus</td>
</tr>
<tr>
<td></td>
<td>ippAlphaPlusPremul</td>
</tr>
</tbody>
</table>

**AlphaComp**

*Combines two images using alpha (opacity) values of both images.*

**Syntax**

**Case 1: Not-in-place operation**

IppStatus ippiAlphaComp_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiAlphaType alphaType);

**Supported values for mod:**

8u_AC1R  16u_AC1R

8u_AC4R  16u_AC4R

IppStatus ippiAlphaComp_<mod>(const Ipp<datatype>* const pSrc1[4], int src1Step, const Ipp<datatype>* const pSrc2[4], int src2Step, Ipp<datatype>* const pDst[4], int dstStep, IppiSize roiSize, IppiAlphaType alphaType);

**Supported values for mod:**

8u_AP4R  16u_AP4R
Case 2: In-place operation

IppStatus ippiAlphaComp_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, IppiAlphaType alphaType);

Supported values for mod:

- 8u_AC4IR
- 16u_AC4IR
- 16s_AC4IR
- 32u_AC4IR
- 32s_AC4IR
- 32f_AC4IR

IppStatus ippiAlphaComp_<mod>(const Ipp<datatype>* const pSrc[4], int srcStep, Ipp<datatype>* const pSrcDst[4], int srcDstStep, IppiSize roiSize, IppiAlphaType alphaType);

Supported values for mod:

- 8u_AP4IR
- 16u_AP4IR

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- pSrc, pSrc1, pSrc2
- srcStep, src1Step, src2Step
- pSrcDst
- pDst
- srcDstStep
- dstStep
- roiSize

Pointers to the source image ROI for pixel-order data. An array of pointers to ROI in the separate source color planes in case of planar data.

Distances, in bytes, between the starting points of consecutive lines in the source images.

Pointer to the source and destination buffer or an array of pointers to separate source and destination color planes for in-place operation.

Pointers to the destination image ROI for pixel-order data. An array of pointers to ROI in the separate destination color planes in case of planar data.

Distance, in bytes, between the starting points of consecutive lines in the source and destination image for in-place operation.

Distance, in bytes, between the starting points of consecutive lines in the destination image.

Size of the source and destination ROI, in pixels.
The composition type to perform. See Table "Possible Values of the Parameter alphaType" for the type value and description.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function performs an image compositing operation on RGBA images using alpha values of both images. The compositing is done by overlaying pixels \((r_A, g_A, b_A, \alpha_A)\) from the foreground image \(pSrc1\) with pixels \((r_B, g_B, b_B, \alpha_B)\) from the background image \(pSrc2\) to produce pixels \((r_C, g_C, b_C, \alpha_C)\) in the resultant image \(pDst\). The alpha values are assumed to be normalized to the range \([0..1]\).

The type of the compositing operation is indicated by the \(alphaType\) parameter. Use Table "Possible Values of the Parameter alphaType" to choose a valid \(alphaType\) value depending on the required composition type. For example, the resulting pixel color components for the OVER operation (see Table "Types of Image Composing Operations") are computed as follows:

\[
\begin{align*}
r_C &= \alpha_A \cdot r_A + (1 - \alpha_A) \cdot \alpha_B \cdot r_B \\
g_C &= \alpha_A \cdot g_A + (1 - \alpha_A) \cdot \alpha_B \cdot g_B \\
b_C &= \alpha_A \cdot b_A + (1 - \alpha_A) \cdot \alpha_B \cdot b_B \\
\end{align*}
\]

The resulting (normalized) alpha value is computed as
\[
\alpha_C = \alpha_A + (1 - \alpha_A) \cdot \alpha_B
\]

This function can be used for unsigned pixel data only.

Return Values
- \(ippStsNoErr\): Indicates no error. Any other value indicates an error or a warning.
- \(ippStsNullPtrErr\): Indicates an error condition if one of the specified pointers is NULL.
- \(ippStsSizeErr\): Indicates an error condition if \(roiSize\) has a field with zero or negative value.

AlphaCompC
Combines two images using constant alpha values.

Syntax
Case 1: Not-in-place operation
\[
\text{IppStatus ippiAlphaCompC}_<\text{mod}>\left(\text{const Ipp<datatype>* }pSrc1, \text{ int src1Step, Ipp<datatype> alpha1, const Ipp<datatype>* }pSrc2, \text{ int src2Step, Ipp<datatype> alpha2, Ipp<datatype>* }pDst, \text{ int dstStep, IppiSize roiSize, IppAlphaType alphaType}\right);
\]

Supported values for \(\text{mod}\):
- 8u_C1R 8u_C3R 8u_C4R 8u_AC4R
- 16u_C1R 16u_C3R 16u_C4R 16u_AC4R
- 16s_C1R
- 32u_C1R
IppStatus ippiAlphaCompC_<mod>(const Ipp<datatype>* const pSrc1[4], int src1Step, Ipp<datatype> alpha1, const Ipp<datatype>* const pSrc2[4], int src2Step, Ipp<datatype> alpha2, Ipp<datatype>* const pDst[4], int dstStep, IppSize roiSize, IppAlphaType alphaType);

**Supported values for** mod:

8u_AP4R  16u_AP4R

**Case 2: In-place operation**

IppStatus ippiAlphaCompC_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype> alpha1, Ipp<datatype>* pSrcDst, int srcDstStep, Ipp<datatype> alpha2, IppSize roiSize, IppAlphaType alphaType);

**Supported values for** mod:

8u_C1IR  16u_C1IR  16s_C1IR  32s_C1IR  32u_C1IR  32f_C1IR
8u_C3IR  16u_C3IR
8u_C4IR  16u_C4IR
8u_AC4IR  16u_AC4IR

IppStatus ippiAlphaCompC_<mod>(const Ipp<datatype>* const pSrc[4], int srcStep, Ipp<datatype> alpha1, Ipp<datatype>* const pSrcDst[4], int srcDstStep, Ipp<datatype> alpha2, IppSize roiSize, IppAlphaType alphaType);

**Supported values for** mod:

8u_AP4IR  16u_AP4IR

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **pSrc1, pSrc2**
  - Pointers to the source image ROI for pixel-order data. An array of pointers to ROI in the separate source color planes in case of planar data.
- **src1Step, src2Step**
  - Distances, in bytes, between the starting points of consecutive lines in the source images.
**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function performs an image compositing operation on one-channel image buffers, three-channel RGB and four-channel RGBA image buffers and on planar images, using constant alpha values alpha1 and alpha2. These values are passed to the function as parameters.

The compositing is done by overlaying pixels from the foreground image ROI pSrc1 with pixels from the background image ROI pSrc2 to produce pixels in the resultant image ROI pDst. The alpha values are normalized to the range [0..1].

The type of the compositing operation is indicated by the alphaType parameter. Use Table “Possible Values of the Parameter alphaType” to choose a valid alphaType value depending on the required composition type.

For example, the resulting pixel color components for the OVER operation (see Table “Types of Image Composing Operations”) are computed as follows:

\[
\begin{align*}
    r_C &= a_1 \cdot r_A + (1 - a_1) \cdot a_2 \cdot r_B \\
    g_C &= a_1 \cdot g_A + (1 - a_1) \cdot a_2 \cdot g_B \\
    b_C &= a_1 \cdot b_A + (1 - a_1) \cdot a_2 \cdot b_B 
\end{align*}
\]

where \( a_1, a_2 \) are the normalised alpha values alpha1, alpha2.

This function can be used for unsigned pixel data only.

**Return Values**

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error condition if one of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error condition if roiSize has a field with zero or negative value.
Example

The code example below shows how to use alpha composition function.

```c
IppStatus acomp( void ) {
  Ipp8u imga[8*8], imgb[8*8], imgc[8*8];
  IppiSize roi = { 8, 8 };
  IppStatus st;
 ippiImageRamp_8u_C1R( imga, 8, roi, 0, 1, ippAxsHorizontal );
 ippiImageRamp_8u_C1R( imgb, 8, roi, 0, 2, ippAxsHorizontal );
  st = ippiAlphaCompC_8u_C1R( imga, 8, 255/3, imgb, 8, 255, imgc, 8, roi, ippAlphaOver );
  printf( "over: a=%d,A=255/3; b=%d,B=255; c=%d //
          c=a*A+b*B*(1-A)\n",imga[6],imgb[6],imgc[6] );
  return st;
}
```

Output

```
over: a=6,A=255/3; b=12,B=255; c=10 // c=a*A+b*B*(1-A)
```

AlphaPremul

_Prefix-multiples pixel values of an image by its alpha values._

Syntax

**Case 1: Not-in-place operation**

```c
IppStatus ippiAlphaPremul_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);
```

Supported values for `mod`:

- 8u_AC4R
- 16u_AC4R

```c
IppStatus ippiAlphaPremul_<mod>(const Ipp<datatype>* const pSrc[4], int srcStep, Ipp<datatype>* const pDst[4], int dstStep, IppiSize roiSize);
```

Supported values for `mod`:

- 8u_AP4R
- 16u_AP4R

**Case 2: In-place operation**

```c
IppStatus ippiAlphaPremul_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);
```

Supported values for `mod`:

- 8u_AC4IR
- 16u_AC4IR

```c
IppStatus ippiAlphaPremul_<mod>(Ipp<datatype>* const pSrcDst[4], int srcDstStep, IppiSize roiSize);
```

Supported values for `mod`:

- 8u_AP4IR
- 16u_AP4IR
Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc  
Pointer to the source image ROI for pixel-order data. An array of pointers to ROI in the separate source color planes in case of planar data.

srcStep  
Distance in bytes between starts of consecutive lines in the source image.

pDst  
Pointer to the destination image ROI for pixel-order data. An array of pointers to ROI in the separate destination color planes in case of planar data.

dstStep  
Distance in bytes between starts of consecutive lines in the destination image.

pSrcDst  
Pointer to the source and destination buffer or an array of pointers to separate source and destination color planes for the in-place operation.

srcDstStep  
Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.

roiSize  
Size of the source and destination ROI in pixels.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts a RGBA source image (pixel order or planar) to the pre-multiplied alpha form. If \((r,g,b,a)\) are the red, green, blue, and alpha values of a pixel, then new pixel values are \((r \times \alpha, g \times \alpha, b \times \alpha, a)\) after execution of this function. Here \(\alpha\) is the pixel normalized alpha value in the range 0 to 1.

The function ippiAlphaPremul can be used for unsigned pixel data only.

Return Values

ippiStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippiStsNullPtrErr  
Indicates an error condition if one of the specified pointers is NULL.

ippiStsSizeErr  
Indicates an error condition if roiSize has a field with zero or negative value.

AlphaPremulC
Pre-multiplies pixel values of an image using constant alpha (opacity) values.
Syntax

Case 1: Not-in-place operation

IppStatus ippiAlphaPremulC_<mod> (const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype> alpha, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

8u_C1R    16u_C1R
8u_C3R    16u_C3R
8u_C4R    16u_C4R
8u_AC4R   16u_AC4R

IppStatus ippiAlphaPremulC_<mod> (const Ipp<datatype>* const pSrc[4], int srcStep, Ipp<datatype> alpha, Ipp<datatype>* const pDst[4], int dstStep, IppiSize roiSize);

Supported values for mod:

8u_AP4R   16u_AP4R

Case 2: In-place operation

IppStatus ippiAlphaPremulC_<mod> (Ipp<datatype> alpha, Ipp<datatype>* pSrcDst, int srcStep, IppiSize roiSize);

Supported values for mod:

8u_C1IR   16u_C1IR
8u_C3IR   16u_C3IR
8u_C4IR   16u_C4IR
8u_AC4IR  16u_AC4IR

IppStatus ippiAlphaPremulC_<mod> (Ipp<datatype> alpha, Ipp<datatype>* const pSrcDst[4], int srcStep, IppiSize roiSize);

Supported values for mod:

8u_AP4IR  16u_AP4IR

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
**Parameters**

- **pSrc**
  Pointer to the source image ROI for pixel-order data. An array of pointers to ROI in the separate source color planes in case of planar data.

- **srcStep**
  Distance in bytes between starts of consecutive lines in the source image.

- **pDst**
  Pointer to the destination image ROI for pixel-order data. An array of pointers to separate ROI in the destination color planes in case of planar data.

- **dstStep**
  Distance in bytes between starts of consecutive lines in the destination image.

- **pSrcDst**
  Pointer to the source and destination image ROI or an array of pointers to ROI in the separate source and destination color planes for the in-place operation.

- **srcDstStep**
  Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.

- **roiSize**
  Size of the source and destination ROI in pixels.

- **alpha**
  Global alpha value used for pre-multiplying pixel values.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts either a one-, three-, four-channel image or planar RGBA image to the pre-multiplied alpha form, using the global alpha value \( \alpha \). For one-, three-, four-channel image buffers, pixel values in each channel are multiplied by \( \alpha \); for RGBA (pixel order and planar) images with \((r,g,b,a)\) pixel values, new pixel values are \((r*\alpha, g*\alpha, b*\alpha, \alpha)\) after execution of this function. Here \( \alpha \) is the normalized \( \alpha \) value in the range 0 to 1.

The function `ippiAlphaPremulC` can be used for unsigned pixel data only.

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**
  Indicates an error condition if one of the specified pointers is NULL.

- **ippStsSizeErr**
  Indicates an error condition if \( \text{roiSize} \) has a field with zero or negative value.
This chapter describes image processing functions that perform different types of image color conversion. The Intel IPP software supports the following image color conversions:

- Color models conversion
- Conversion from color to gray scale and vice versa
- Different types of format conversion:
  - from pixel-order to planar format and vice versa
  - changing number of channels or planes
  - changing sampling format
  - altering order of samples or planes
- Gamma correction
- Reduction from high bit resolution color to low bit resolution color
- Intensity transformation using lookup tables
- Color twist
- Color keying

All Intel IPP color conversion functions perform point operations on pixels of the source image. For a given destination pixel, the resultant channel values are computed using channel values of the corresponding source pixel only, and not involving any neighborhood pixels. Thus, the rectangular region of interest (ROI, see Regions of Interest in Intel IPP) used in function operations may extend to the size of the whole image.

This chapter starts with introductory material that discusses color space models essential for understanding of the Intel IPP color conversion functions.

For more information about color spaces and color conversion techniques, see [Jack01], [Rogers85], and [Foley90].

Gamma Correction

Gamma correction of images is used to optimize the usage of data type depth when encoding an image by taking advantage of the non-linear manner in which humans perceive light and color. This non-linearity must be compensated to achieve correct color reproduction. To do this, luminance of each of the linear red, green, and blue components is reduced to a non-linear form using an inverse transformation. This process is called gamma correction.

The Intel IPP functions use the following basic equations to convert an RGB image to a gamma-corrected R’G’B’ image:

For \( R, G, B < 0.018 \):

\[
R' = 4.5R \\
G' = 4.5G \\
B' = 4.5B
\]

For \( R, G, B \geq 0.018 \):

\[
R' = 1.099R^{0.45} - 0.099 \\
G' = 1.099G^{0.45} - 0.099 \\
B' = 1.099B^{0.45} - 0.099
\]

Note that the channel intensity values are normalized to fit in the range [0..1]. The gamma value is equal to \( 1/0.45 = 2.22 \) in conformity with ITU Rec.709 specification (see [ITU709]).
CIE Chromaticity Diagram and Color Gamut

Figure CIE xyY Chromaticity Diagram and Color Gamut presents a diagram of all visible colors. It is called a chromaticity diagram and was developed as a result of the experimental investigations performed by CIE (International Commission on Illumination, http://members.eunet.at/cie). The diagram presents visible colors as a function of \( x \) (red) and \( y \) (green) components called chromaticity coordinates. Positions of various spectrum colors (from violet to red) are indicated as the points of a tongue-shaped curve called spectrum locus. The straight line connecting the ends of the curve is called the purple line. The point of equal energy represents the CIE standard for white light. Any point within the diagram represents some mixture of spectrum colors. The pure or fully saturated colors lie on the spectrum locus. A straight-line segment joining any two points in the diagram defines all color variations that can be obtained by additively combining these two colors. A triangle with vertices at any three points determine the gamut of colors that can be obtained by combining corresponding three colors.

The structure of the human eye that distinguishes three different stimuli, establishes the three-dimensional nature of color. The color may be described with a set of three parameters called tristimulus values, or components. These values may, for example, be dominant wavelength, purity, and luminance, or so-called primary colors: red, green, and blue.

The chromaticity diagram exhibits that the gamut of any three fixed colors cannot enclose all visible colors. For example, Figure CIE xyY Chromaticity Diagram and Color Gamut shows schematically the gamut of reproducible colors for the RGB primaries of a typical color CRT monitor, CMYK color printing, and for the NTSC television.

CIE xyY Chromaticity Diagram and Color Gamut

The purpose of a color model is to facilitate the specification of colors in some standard generally accepted way. In essence, a color model is a specification of a 3-D coordinate system and a subspace within that system where each color is represented by a single point.
Each industry that uses color employs the most suitable color model. For example, the RGB color model is used in computer graphics, YUV or YCbCr are used in video systems, PhotoYCC* is used in PhotoCD* production and so on. Transferring color information from one industry to another requires transformation from one set of values to another. Intel IPP provides a wide number of functions to convert different color spaces to RGB and vice versa.

**RGB Color Model**

In the RGB model, each color appears as a combination of red, green, and blue. This model is called additive, and the colors are called primary colors. The primary colors can be added to produce the secondary colors of light (see Figure "Primary and Secondary Colors for RGB and CMYK Models") - magenta (red plus blue), cyan (green plus blue), and yellow (red plus green). The combination of red, green, and blue at full intensities makes white.

**Primary and Secondary Colors for RGB and CMYK Models**

The color subspace of interest is a cube shown in Figure "RGB and CMY Color Models" (RGB values are normalized to 0..1), in which RGB values are at three corners; cyan, magenta, and yellow are the three other corners, black is at their origin; and white is at the corner farthest from the origin.

The gray scale extends from black to white along the diagonal joining these two points. The colors are the points on or inside the cube, defined by vectors extending from the origin.

Thus, images in the RGB color model consist of three independent image planes, one for each primary color. As a rule, the Intel IPP color conversion functions operate with non-linear gamma-corrected images R’G’B’.

The importance of the RGB color model is that it relates very closely to the way that the human eye perceives color. RGB is a basic color model for computer graphics because color displays use red, green, and blue to create the desired color. Therefore, the choice of the RGB color space simplifies the architecture and design of the system. Besides, a system that is designed using the RGB color space can take advantage of a large number of existing software routines, because this color space has been around for a number of years.

**RGB and CMY Color Models**
However, RGB is not very efficient when dealing with real-world images. To generate any color within the RGB color cube, all three RGB components need to be of equal pixel depth and display resolution. Also, any modification of the image requires modification of all three planes.

**CMYK Color Model**

The CMYK color model is a subset of the RGB model and is primarily used in color print production. CMYK is an acronym for cyan, magenta, and yellow along with black (noted as K). The CMYK color space is subtractive, meaning that cyan, magenta yellow, and black pigments or inks are applied to a white surface to subtract some color from white surface to create the final color. For example (see Figure "Primary and Secondary Colors for RGB and CMYK Models"), cyan is white minus red, magenta is white minus green, and yellow is white minus blue. Subtracting all colors by combining the CMY at full saturation should, in theory, render black. However, impurities in the existing CMY inks make full and equal saturation impossible, and some RGB light does filter through, rendering a muddy brown color. Therefore, the black ink is added to CMY. The CMY cube is shown in Figure "RGB and CMY Color Models", in which CMY values are at three corners; red, green, and blue are the three other corners, white is at the origin; and black is at the corner farthest from the origin.

**YUV Color Model**

The YUV color model is the basic color model used in analogue color TV broadcasting. Initially YUV is the re-coding of RGB for transmission efficiency (minimizing bandwidth) and for downward compatibility with black-and white television. The YUV color space is "derived" from the RGB space. It comprises the luminance (Y) and two color difference (U, V) components. The luminance can be computed as a weighted sum of red, green and blue components; the color difference, or chrominance, components are formed by subtracting luminance from blue and from red.

The principal advantage of the YUV model in image processing is decoupling of luminance and color information. The importance of this decoupling is that the luminance component of an image can be processed without affecting its color component. For example, the histogram equalization of the color image in the YUV format may be performed simply by applying histogram equalization to its Y component.

There are many combinations of YUV values from nominal ranges that result in invalid RGB values, because the possible RGB colors occupy only part of the YUV space limited by these ranges. Figure "RGB Colors Cube in the YUV Color Space" shows the valid color block in the YUV space that corresponds to the RGB color cube RGB values that are normalized to [0..1]).

The Y′U′V′ notation means that the components are derived from gamma-corrected R′G′B′. Weighted sum of these non-linear components forms a signal representative of luminance that is called luma Y′. (Luma is often loosely referred to as luminance, so you need to be careful to determine whether a particular author assigns a linear or non-linear interpretation to the term luminance).

The Intel IPP functions use the following basic equation ([Jack01]) to convert between gamma-corrected R′G′B′ and Y′U′V′ models:

\[
Y' = 0.299*R' + 0.587*G' + 0.114*B' \\
U' = -0.147*R' - 0.289*G' + 0.436*B' = 0.492*(B' - Y') \\
V' = 0.615*R' - 0.515*G' - 0.100*B' = 0.877*(R' - Y') \\
R' = Y' + 1.140*V' \\
G' = Y' - 0.394*U' - 0.581*V'
\]
There are several YUV sampling formats such as 4:4:4, 4:2:2, and 4:2:0 that are supported by the Intel IPP color conversion functions and are described later in this chapter in **Image Downsampling**.

**YCbCr and YCCK Color Models**

The YCbCr color space is used for component digital video and was developed as part of the ITU-R BT.601 Recommendation. YCbCr is a scaled and offset version of the YUV color space.

The Intel IPP functions use the following basic equations [Jack01] to convert between $R'G'B'$ in the range 0-255 and $Y'Cb'Cr'$ (this notation means that all components are derived from gamma-corrected $R'G'B'$):

$Y' = 0.257*R' + 0.504*G' + 0.098*B' + 16$

$Cb' = -0.148*R' - 0.291*G' + 0.439*B' + 128$

$Cr' = 0.439*R' - 0.368*G' - 0.071*B' + 128$

$R' = 1.164*(Y'-16) + 1.596*(Cr'-128)$

$G' = 1.164*(Y'-16) - 0.813*(Cr'-128) - 0.392*(Cb'-128)$

$B' = 1.164*(Y'-16) + 2.017*(Cb'-128)$

Possible RGB colors occupy only part of the YCbCr color space (see Figure "RGB Colors Cube in the YCbCr Space") limited by the nominal ranges, therefore there are many YCbCr combinations that result in invalid RGB values.
There are several YCbCr sampling formats such as 4:4:4, 4:2:2, 4:1:1, and 4:2:0, which are supported by the Intel IPP color conversion functions and are described later in this chapter in Image Downsampling.

**RGB Colors Cube in the YCbCr Space**

*PhotoYCC Color Model*

The Kodak* PhotoYCC* was developed for encoding Photo CD* image data. It is based on both the ITU Recommendations 601 and 709, using luminance-chrominance representation of color like in BT.601 YCbCr and BT.709 ([ITU709]). This model comprises luminance (Y) and two color difference, or chrominance (C1, C2) components. The PhotoYCC is optimized for the color photographic material, and provides a color gamut that is greater than the one that can currently be displayed.

The Intel IPP functions use the following basic equations [Jack01] to convert non-linear gamma-corrected R'G'B' to Y'C'C':

\[
Y' = 0.213*R' + 0.419*G' + 0.081*B'
\]

\[
C1' = -0.131*R' - 0.256*G' + 0.387*B' + 0.612
\]

\[
C2' = 0.373*R' - 0.312*R' - 0.061*B' + 0.537
\]

The equations above are given on the assumption that R', G', and B' values are normalized to the range [0..1].

Since the PhotoYCC model attempts to preserve the dynamic range of film, decoding PhotoYCC images requires selection of a color space and range appropriate for the output device. Thus, the decoding equations are not always the exact inverse of the encoding equations. The following equations [Jack01] are used in Intel IPP to generate R'G'B' values for driving a CRT display and require a unity relationship between the luma in the encoded image and the displayed image:

\[
R' = 0.981 * Y + 1.315 * (C2 - 0.537)
\]

\[
G' = 0.981 * Y - 0.311 * (C1 - 0.612) - 0.669 * (C2 - 0.537)
\]

\[
B' = 0.981 * Y + 1.601 * (C1 - 0.612)
\]

The equations above are given on the assumption that source Y, C1 and C2 values are normalized to the range [0..1], and the display primaries have the chromaticity values in accordance with [ITU709] specifications.
The possible RGB colors occupy only part of the YCC color space (see Figure "RGB Colors in the YCC Color Space") limited by the nominal ranges, therefore there are many YCC combinations that result in invalid RGB values.

**RGB Colors in the YCC Color Space**

![RGB Colors in the YCC Color Space](image)

**YCoCg Color Models**

The YCoCg color model was developed to increase the effectiveness of the image compression [Malvar03]. This color model comprises the luminance (Y) and two color difference components (Co - offset orange, Cg - offset green).

The Intel IPP functions use the following simple basic equations [Malvar03] to convert between RGB and YCoCg:

\[
Y = \frac{R}{4} + \frac{G}{2} + \frac{B}{4}
\]

\[
Co = \frac{R}{2} - \frac{B}{2}
\]

\[
Cg = -\frac{R}{4} + \frac{G}{2} - \frac{B}{4}
\]

\[
R = Y + Co - Cg
\]

\[
G = Y + Cg
\]

\[
B = Y - Co - Cg
\]

A variation of this color space which is called YCoCg-R, enables transformation reversibility with a smaller dynamic range requirements than does YCoCg [Malvar03-1].
The possible RGB colors occupy only part of the YCoCg color space (see Figure "RGB Color Cube in the YCoCg Color Space") limited by the nominal ranges, therefore there are many YCoCg combinations that result in invalid RGB values.

**RGB Color Cube in the YCoCg Color Space**

**HSV, and HLS Color Models**

The HLS (hue, lightness, saturation) and HSV (hue, saturation, value) color models were developed to be more "intuitive" in manipulating with color and were designed to approximate the way humans perceive and interpret color.

*Hue* defines the color itself. The values for the hue axis vary from 0 to 360 beginning and ending with red and running through green, blue and all intermediary colors.

*Saturation* indicates the degree to which the hue differs from a neutral gray. The values run from 0, which means no color saturation, to 1, which is the fullest saturation of a given hue at a given illumination.

Intensity component - *lightness* (HLS) or *value* (HSV), indicates the illumination level. Both vary from 0 (black, no light) to 1 (white, full illumination). The difference between the two is that maximum saturation of hue (S=1) is at value V=1 (full illumination) in the HSV color model, and at lightness L=0.5 in the HLS color model.

The HSV color space is essentially a cylinder, but usually it is represented as a cone or hexagonal cone (hexcone) as shown in the Figure "HSV Solid", because the hexcone defines the subset of the HSV space with valid RGB values. The *value* V is the vertical axis, and the vertex V=0 corresponds to black color. Similarly, a color solid, or 3D-representation, of the HLS model is a double hexcone (Figure "HSV Solid") with *lightness* as the axis, and the vertex of the second hexcone corresponding to white.
Both color models have intensity component decoupled from the color information. The HSV color space yields a greater dynamic range of saturation. Conversions from RGBToHSV/RGBToHSV and vice-versa in Intel IPP are performed in accordance with the respective pseudocode algorithms [Rogers85] given in the descriptions of corresponding conversion functions.

**HSV Solid**

**HLS Solid**
**CIE XYZ Color Model**

The XYZ color space is an international standard developed by the CIE (Commission Internationale de l'Eclairage). This model is based on three hypothetical primaries, XYZ, and all visible colors can be represented by using only positive values of X, Y, and Z. The CIE XYZ primaries are hypothetical because they do not correspond to any real light wavelengths. The Y primary is intentionally defined to match closely to luminance, while X and Z primaries give color information. The main advantage of the CIE XYZ space (and any color space based on it) is that this space is completely device-independent. The chromaticity diagram in Figure "CIE xyY Chromaticity Diagram and Color Gamut" is in fact a two-dimensional projection of the CIE XYZ sub-space. Note that arbitrarily combining X, Y, and Z values within nominal ranges can easily lead to a "color" outside of the visible color spectrum.

The position of the block of RGB-representable colors in the XYZ space is shown in Figure "RGB Colors Cube in the XYZ Color Space".

**RGB Colors Cube in the XYZ Color Space**

![RGB Colors Cube in the XYZ Color Space](image)

Intel IPP functions use the following basic equations [Rogers85], to convert between gamma-corrected R’G’B’ and CIE XYZ models:

\[
\begin{align*}
X &= 0.412453 \times R' + 0.35758 \times G' + 0.180423 \times B' \\
Y &= 0.212671 \times R' + 0.71516 \times G' + 0.072169 \times B' \\
Z &= 0.019334 \times R' + 0.119193 \times G' + 0.950227 \times B'
\end{align*}
\]

The equations for X, Y, Z calculation are given on the assumption that R’, G’, and B’ values are normalized to the range [0..1].

\[
\begin{align*}
R' &= 3.240479 \times X - 1.53715 \times Y - 0.498535 \times Z \\
G' &= -0.969256 \times X + 1.875991 \times Y + 0.041556 \times Z \\
B' &= 0.055648 \times X - 0.204043 \times Y + 1.057311 \times Z
\end{align*}
\]

The equations for R’, G’, and B’ calculation are given on the assumption that X, Y, and Z values are in the range [0..1].

**CIE LUV and CIE Lab Color Models**

The CIE LUV and CIE Lab color models are considered to be perceptually uniform and are referred to as uniform color models. Both are uniform derivations from the standard CIE XYZ space. "Perceptually uniform" means that two colors that are equally distant in the color space are equally distant perceptually. To
accomplish this approach, a uniform chromaticity scale (UCS) diagram was proposed by CIE (Figure "CIE $u',v'$ Uniform Chromaticity Scale Diagram"). The UCS diagram uses a mathematical formula to transform the XYZ values or x, y coordinates (Figure "CIE $xyY$ Chromaticity Diagram and Color Gamut"), to a new set of values that present a visually more accurate two-dimensional model. The Y lightness scale is replaced with a new scale called L that is approximately uniformly spaced but is more indicative of the actual visual differences. Chrominance components are U and V for CIE LUV, and $a$ and $b$ (referred to also respectively as red/blue and yellow/blue chrominances) in CIE Lab. Both color spaces are derived from the CIE XYZ color space.

**CIE $u',v'$ Uniform Chromaticity Scale Diagram**

The CIE LUV color space is derived from CIE XYZ as follows ([Rogers85]),

\[
L = 116. \cdot (Y/Y_n)^{1/3} - 16. \\
U = 13. \cdot L \cdot (u - u_n) \\
V = 13. \cdot L \cdot (v - v_n)
\]

where

\[
u = 4.\cdot X / (X + 15.\cdot Y + 3.\cdot Z) \\
v = 9.\cdot Y / (X + 15.\cdot Y + 3.\cdot Z) \\
u_n = 4.\cdot x_n / ( -2.\cdot x_n + 12.\cdot y_n + 3. ) \\
v_n = 9.\cdot y_n / ( -2.\cdot x_n + 12.\cdot y_n + 3. )
\]

Inverse conversion is performed in accordance with equations:

\[
Y = Y_n \cdot ((L + 16.) / 116.)^{3}. \\
X = -9.\cdot Y \cdot u / ((u - 4.)* v - u * v ) \\
Z = (9.\cdot Y - 15*v*Y - v*X) / 3. \cdot v
\]

where

\[
u = U / (13.\cdot L) + u_n \\
v = V / (13.\cdot L) + v_n
\]

and $u_n$, $v_n$ are defined above.
Here \( x_n = 0.312713 \), \( y_n = 0.329016 \) are the CIE chromaticity coordinates of the D65 white point ([ITU709]), and \( Y_n = 1.0 \) is the luminance of the D65 white point. The values of the L component are in the range [0..100], U component in the range [-134..220], and V component in the range [-140..122].

The RGB-representable colors occupy only part of the LUV color space (see Figure 6-12) limited by the nominal ranges, therefore there are many LUV combinations that result in invalid RGB values.

**RGB Color Cube in the CIE LUV Color Space**

The CIE Lab color space is derived from CIE XYZ as follows:

\[
L = 116. \times (Y/Y_n)^{1/3} - 16 \quad \text{for } Y/Y_n > 0.008856
\]

\[
L = 903.3 \times (Y/Y_n)^{1/3} \quad \text{for } Y/Y_n \leq 0.008856
\]

\[
a = 500. \times [f(X/X_n) - f(Y/Y_n)]
\]

\[
b = 200. \times [f(Y/Y_n) - f(Z/Z_n)]
\]

where

\[
f(t) = t^{1/3} - 16 \quad \text{for } t > 0.008856
\]

\[
f(t) = 7.787 \times t + 16/116 \quad \text{for } t \leq 0.008856
\]

Here \( Y_n = 1.0 \) is the luminance, and \( X_n = 0.950455 \), \( Z_n = 1.088753 \) are the chrominances for the D65 white point.

The values of the L component are in the range [0..100], \( a \) and \( b \) component values are in the range [-128..127].

Inverse conversion is performed in accordance with equations:

\[
Y = Y_n \times P^3.
\]

\[
X = X_n \times (P + a/500.)^3.
\]

\[
Z = Z_n \times (P - b/200.)^3.
\]

where

\[
P = (L +16)/116.
\]
Image Downsampling

Conventionally, digital color images are represented by setting specific values of the color space coordinates for each pixel. Color spaces with decoupled luminance and chrominance coordinates (YUV type) allow the number of bits required for acceptable color description of an image to be reduced. This reduction is based on greater sensitivity of the human eye to changes in luminance than to changes in chrominance. The idea behind this approach is to set individual value of luminance component to each pixel, while assigning the same color (chrominance components) to certain groups of pixels (sometimes called *macropixels*) in accordance with some specific rules. This process is called *downsampling* and there are different sampling formats depending on the underlying scheme.

The following sampling formats are supported by the Intel IPP image processing functions (excluding the JPEG functions):

4:4:4 YUV (YCbCr) - conventional format, no downsampling, Y, U(Cb), V(Cr) components are sampled at every pixel. If each component takes 8 bits, than every pixel requires 24 bits. This format is often denoted as YUV (YCbCr) with the 4:4:4 descriptor omitted.

4:2:2 YUV (YCbCr) - uses the 2:1 horizontal downsampling. It means that the Y component is sampled at each pixel, while U(Cb) and V(Cr) components are sampled every 2 pixels in horizontal direction. If each component takes 8 bits, the pair of pixels requires 32 bits.

4:1:1 YCbCr - uses the 4:1 horizontal downsampling. It means that the Y component is sampled at each pixel, while Cb and Cr components are sampled every 4 pixels horizontally. If each component takes 8 bits, each four horizontal pixels require 48 bits.

4:2:0 YUV (YCbCr) - uses the 2:1 horizontal downsampling and the 2:1 vertical downsampling. Y is sampled at each pixel, U(Cb) and V(Cr) are sampled at every block of 2x2 pixels. If each component takes 8 bits, each four-pixel block requires 48 bits.

In JPEG compression, downsampling has specific distinctive features and is denoted in a slightly different way. In JPEG domain, sampling formats determine the structure of minimal coded units, or MCUs. Therefore, the Intel IPP functions specific for a JPEG codec, support the following sampling formats:

4:4:4 YCbCr - for every 8x8 block of Y samples, there is one 8x8 block of each Cb and Cr samples.

4:2:2 YCbCr - for every two horizontal 8x8 blocks of Y samples, there is one 8x8 block of each Cb and Cr samples.

4:1:1 YCbCr - for every four (two in horizontal and two in vertical direction) 8x8 blocks of Y samples, there is one 8x8 block of each Cb and Cr samples.

Structure of the corresponding MCU for each of these sampling formats is shown in Figure MCU Structure for Different JPEG Sampling Formats.
**RGB Image Formats**

In addition to the 24-bit-per-pixel RGB/BGR image formats, the Intel IPP color conversion functions support 32-bit-per-pixel RGB/BGR formats, which include three RGB channels plus alpha channel. For 24-bit formats, each color is one byte, every pixel is three bytes. For 32-bit formats, each color is one byte and alpha component is one byte, which yields four bytes per pixel. Memory layout for these formats is given in Table "Pixel-Order Image Formats".

For 16-bit formats, every pixel is two bytes and each color occupies a specified number of bits. The figure below shows all the supported 16-bit-per-pixel formats and their memory layout (bit order):

16-bit pixel formats

<table>
<thead>
<tr>
<th>16-bit pixel formats</th>
<th>High-order byte</th>
<th>Low-order byte</th>
</tr>
</thead>
<tbody>
<tr>
<td>RGB565</td>
<td>B4 B3 B2 B1 B0 G5 G4 G3</td>
<td>G2 G1 G0 R4 R3 R2 R1 R0</td>
</tr>
<tr>
<td>RGB555</td>
<td>X B4 B3 B2 B1 B0 G4 G3</td>
<td>G2 G1 G0 R4 R3 R2 R1 R0</td>
</tr>
<tr>
<td>RGB444</td>
<td>X X X B3 B2 B1 B0</td>
<td>G3 G2 G1 G0 R3 R2 R1 R0</td>
</tr>
<tr>
<td>BGR565</td>
<td>R4 R3 R2 R1 R0 G5 G4 G3</td>
<td>G2 G1 G0 B4 B3 B2 B1 B0</td>
</tr>
<tr>
<td>BGR555</td>
<td>X R4 R3 R2 R1 R0 G4 G3</td>
<td>G2 G1 G0 B4 B3 B2 B1 B0</td>
</tr>
<tr>
<td>BGR444</td>
<td>X X X X R3 R2 R1 R0</td>
<td>G3 G2 G1 G0 B3 B2 B1 B0</td>
</tr>
</tbody>
</table>

R - Red,  G - Green,  B - Blue,  X - free bit

**Pixel and Planar Image Formats**

Data storage for an image can be pixel-oriented or planar-oriented (planar). For images in pixel order, all channel values for each pixel are clustered and stored consecutively. Their layout depends on the color model and downsampling scheme.

Table “Pixel-Order Image Formats” lists all pixel-order image formats that are supported by the Intel IPP color conversion functions and shows the corresponding channel values order (here, group of underlined symbols represents one pixel and symbol A denotes alpha-channel value). The last column of this table gives an example of an Intel IPP color conversion function that uses the respective image format.

**Pixel-Order Image Formats**

<table>
<thead>
<tr>
<th>Image Format</th>
<th>Number of Channels</th>
<th>Channel Values Order</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>RGB</td>
<td>3</td>
<td>R0 G0 B0 R1 G1 B1 R2 G2 B2</td>
<td>ippiRGBToYUV_8u_C3R</td>
</tr>
<tr>
<td>RGB444</td>
<td></td>
<td></td>
<td>ippiYCbCrToRGB444_8u16u_C3R</td>
</tr>
<tr>
<td>RGB555</td>
<td></td>
<td></td>
<td>ippiYCbCrToRGB555_8u16u_C3R</td>
</tr>
<tr>
<td>RGB565</td>
<td></td>
<td></td>
<td>ippiYCbCrToRGB565_8u16u_C3R</td>
</tr>
<tr>
<td>RGB</td>
<td>4</td>
<td>R0 G0 B0 A0 R1 G1 B1 A1</td>
<td>ippiRGBToYUV_8u_AC4R</td>
</tr>
<tr>
<td>BGR</td>
<td>3</td>
<td>B0 G0 R0 B1 G1 R1 R2 G2 R2</td>
<td>ippiYCbCrToBGR_8u_P3C3R</td>
</tr>
<tr>
<td>BGR444</td>
<td></td>
<td></td>
<td>ippiYCbCrToBGR444_8u16u_C3R</td>
</tr>
</tbody>
</table>
### Planar Image Formats

<table>
<thead>
<tr>
<th>Image Format</th>
<th>Number of Planes</th>
<th>Planes Layout</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>RGB</td>
<td>3</td>
<td>R G B</td>
<td>see Figure below, a</td>
</tr>
<tr>
<td>YUV</td>
<td>3</td>
<td>Y U V</td>
<td>see Figure below, a</td>
</tr>
<tr>
<td>4:2:2 YUV</td>
<td>3</td>
<td>Y U V</td>
<td>see Figure below, b</td>
</tr>
</tbody>
</table>

Planar image formats supported by the Intel IPP color conversion functions are listed in Table "Planar Image Formats" along with examples of the Intel IPP functions using that format. Planes layout and their relative sizes are shown in Figure Plane Size and Layout: 3-planes Images and Figure Plane Size and Layout: 2-planes Images.
<table>
<thead>
<tr>
<th>Image Format</th>
<th>Number of Planes</th>
<th>Planes Layout</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:2:0 YUV</td>
<td>3</td>
<td>Y U V</td>
<td>see Figure below, d</td>
</tr>
<tr>
<td>YCbCr</td>
<td>3</td>
<td>Y Cb Cr</td>
<td>see Figure below, a</td>
</tr>
<tr>
<td>4:2:2 YCbCr</td>
<td>3</td>
<td>Y Cb Cr</td>
<td>see Figure below, b</td>
</tr>
<tr>
<td>4:1:1 YCbCr</td>
<td>3</td>
<td>Y Cb Cr</td>
<td>see Figure below, c</td>
</tr>
<tr>
<td>4:1:1 YCbCr</td>
<td>2</td>
<td>Y CbCr</td>
<td>see Figure below for 2-planes images, a</td>
</tr>
<tr>
<td>4:2:0 YCbCr</td>
<td>3</td>
<td>Y Cb Cr</td>
<td>see Figure below, d</td>
</tr>
<tr>
<td>4:2:0 YCbCr</td>
<td>2</td>
<td>Y CbCr</td>
<td>see Figure below for 2-planes images, b</td>
</tr>
<tr>
<td>Image Format</td>
<td>Number of Planes</td>
<td>Planes Layout</td>
<td>Example</td>
</tr>
<tr>
<td>---------------</td>
<td>------------------</td>
<td>---------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>4:2:0 YCrCb</td>
<td>3</td>
<td>Y Cr Cb</td>
<td>see Figure below, d</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ippiYCrCb420ToYCbCr422_8u_P3R</td>
</tr>
</tbody>
</table>

### Plane Size and Layout - 3-planes Images

- **Plane 1, Plane 2, Plane 3**
- **Plane Size and Layout**
- **Example**
- **a)** no downsampling, or sampling 4:4:4
- **b)** sampling 4:2:2
- **c)** sampling 4:1:1
- **d)** sampling 4:2:0

### Plane Size and Layout - 2-planes Images

- **Plane 1, Plane 2**
- **Plane Size and Layout**
- **Example**
- **a)** sampling 4:1:1
- **b)** sampling 4:2:0
Color Model Conversion

RGBToYUV
Converting an RGB image to the YUV color model.

Syntax
Case 1: Operation on pixel-order data
IppStatus ippiRGBToYUV_<mod>(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:
   8u_C3R    8u_AC4R

Case 2: Operation on planar data
IppStatus ippiRGBToYUV_8u_P3R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst[3], int dstStep, IppiSize roiSize);

Case 3: Conversion from pixel-order to planar data
IppStatus ippiRGBToYUV_8u_C3P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep, IppiSize roiSize);
IppStatus ippiRGBToYUV_8u_AC4P4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[4], int dstStep, IppiSize roiSize);

Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
pSrc Pointer to the source image ROI for pixel-order data. An array of pointers to the source image ROI in separate color planes in case of planar data.
srcStep Distance in bytes between starts of consecutive lines in the source image.
pDst Pointer to the destination ROI for pixel-order data. An array of pointers to destination buffers in separate color planes in case of planar data.
dstStep Distance in bytes between starts of consecutive lines in the destination image.
roiSize Size of the source and destination ROI in pixels.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the gamma-corrected \( R'G'B' \) image \( p_{Source} \) to the \( Y'U'V' \) image \( p_{Destination} \) (see Figure Converting an RGB image to YUV) according to the following formulas:

\[
Y' = 0.299 \times R' + 0.587 \times G' + 0.114 \times B' \\
U' = -0.147 \times R' - 0.289 \times G' + 0.436 \times B' = 0.492 \times (B' - Y') \\
V' = 0.615 \times R' - 0.515 \times G' - 0.100 \times B' = 0.877 \times (R' - Y')
\]

For digital RGB values in the range \([0..255]\), \( Y' \) has the range \([0..255]\), \( U \) varies in the range \([-112..+112]\), and \( V \) in the range \([-157..+157]\). To fit in the range of \([0..255]\), a constant value 128 is added to computed \( U \) and \( V \) values, and \( V \) is then saturated.

### Converting an RGB image to YUV

![source image](image1) ![destination image](image2)

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if \( p_{Source} \) or \( p_{Destination} \) pointer is NULL.
- **ippStsSizeErr**: Indicates an error condition if \( roiSize \) has a field with a zero or negative value.

**Example**

The code example below shows how to use the function `ippiRGBToYUV_8u_C3R`.

```c
#define nChannels 3

int main ()
{
    Ipp8u src [3*3* nChannels ] = {
        255, 0, 0, 255, 0, 0, 255, 0, 0,
        0, 255, 0, 0, 255, 0, 0, 255, 0,
        0, 0, 255, 0, 0, 255, 0, 0, 255};
    Ipp8u dst [3*3* nChannels ];
    IppSize roiSize = { 3, 3 };  
    IppStatus st = ippStsNoErr ;
    int srcStep = 3* nChannels ;  
    int dstStep = 3* nChannels ;
    st = ippiRGBToYUV_8u_C3_R ( src , srcStep , dst , dstStep , roiSize );
    if ( st == ippStsNoErr) {
        printf("\n *************  passed ****************\n");
    }else{
        printf("\n *************  failed ****************\t");
    }

    return 0;
}
```
**YUVToRGB**

Converts a YUV image to the RGB color model.

**Syntax**

**Case 1: Operation on pixel-order data**

```c
IppStatus ippiYUVToRGB_<mod>(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
```

Supported values for `mod`:

- `8u_C3R`
- `8u_AC4R`

```c
IppStatus ippiYUVToRGB_8u_C3C4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);
```

**Case 2: Operation on planar data**

```c
IppStatus ippiYUVToRGB_8u_P3R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst[3], int dstStep, IppiSize roiSize);
```

**Case 3: Conversion from planar to pixel-order data**

```c
IppStatus ippiYUVToRGB_8u_P3C3R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
```

**Include Files**

`ippcc.h`

**Domain Dependencies**

**Headers:** `ippcore.h`, `ippvm.h`, `ipps.h`, `ippi.h`

**Libraries:** `ippcore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`

**Parameters**

- `pSrc`
  - Pointer to the source buffer for pixel-order data. An array of pointers to separate source color planes in case of planar data.
- `srcStep`
  - Distance in bytes between starts of consecutive lines in the source image.
- `pDst`
  - Pointer to the destination buffer for pixel-order data. An array of pointers to separate destination color planes in case of planar data.
$dstStep$  
Distance in bytes between starts of consecutive lines in the destination image.

$aval$  
Constant value to create the fourth channel.

$roiSize$  
Size of the source and destination ROI in pixels.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the Y'U'V' image $pSrc$ to the gamma-corrected R'G'B' image $pDst$ according to the following formulas:

\[
R' = Y' + 1.140*V'  
G' = Y' - 0.394*U' - 0.581*V'  
B' = Y' + 2.032*U'  
\]

**Return Values**

- **ippStsNoErr**  
Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**  
Indicates an error condition if $pSrc$ or $pDst$ is NULL.

- **ippStsSizeErr**  
Indicates an error condition if $roiSize$ has a field with a zero or negative value.

**RGBToYUV422**  
*Converts an RGB image to the YUV color model; uses 4:2:2 sampling.*

**Syntax**

**Case 1: Operation on pixel-order data**

IppStatus ippiRGBToYUV422_8u_C3C2R(const Ipp8u* $pSrc$, int $srcStep$, Ipp8u* $pDst$, int $dstStep$, IppiSize $roiSize$);

**Case 2: Operation on planar data with ROI**


**Case 3: Operation on planar data without ROI**


**Case 4: Conversion from pixel-order to planar data with ROI**


**Case 5: Conversion from pixel-order to planar data without ROI**

IppStatus ippiRGBToYUV422_8u_C3P3(const Ipp8u* $pSrc$, Ipp8u* $pDst[3]$, IppiSize $imgSize$);

**Include Files**

ippcc.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- **pSrc**: Pointer to the source image buffer for pixel-order image. An array of pointers to the source image buffer in each color plane for planar image.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image for operations with ROI.
- **pDst**: Pointer to the destination image buffer for pixel-order image. An array of pointers to the destination image buffer in each color plane for planar image.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image for operations with ROI. An array of three values for planar image.
- **roiSize**: Size of the source and destination ROI in pixels.
- **imgSize**: Size of the source and destination images in pixels for operations without ROI.

Description

This function converts the gamma-corrected R'G'B' image pSrc to the Y'U'V' image pDst with 4:2:2 sampling format, according to the same formulas as the function ippiRGBToYUV does. For more details on this sampling format, see Table “Pixel-Order Image Formats” and Table “Planar Image Formats”.

For digital RGB values in the range [0..255], Y' has the range [0..255], U varies in the range [-112..+112], and V in the range [-157..+157]. To fit in the range of [0..255], the constant value 128 is added to computed U and V values, and V is then saturated.

Some function flavors operates with ROI (see Regions of Interest in Intel IPP). The function flavors that does not use ROI operate on the assumption that both the source and destination images have the same size and occupy a contiguous memory area, which means that image rows are not padded with zeroes. In this case the step parameters are not needed.

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if pSrc or pDst pointer is NULL.
- **ippStsSizeErr**: Indicates an error condition if roiSize or imgSize has a field with a zero or negative value.

YUV422ToRGB

*Converts a YUV image with the 4:2:2 sampling to the RGB color model.*

Syntax

**Case 1: Operation on pixel-order data**

IppStatus ippiYUV422ToRGB_8u_C2C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
Case 2: Operation on planar data with ROI

IppStatus ippiYUV422ToRGB_8u_P3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst[3], int dstStep, IppiSize roiSize);

Case 3: Operation on planar data without ROI

IppStatus ippiYUV422ToRGB_8u_P3(const Ipp8u* pSrc[3], Ipp8u* pDst[3], IppiSize imgSize);

Case 4: Conversion from planar to pixel-order data with ROI

IppStatus ippiYUV422ToRGB_<mod>(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

8u_P3C3R  8u_P3AC4R

Case 5: Conversion from planar to pixel-order data without ROI

IppStatus ippiYUV422ToRGB_8u_P3C3(const Ipp8u* pSrc[3], Ipp8u* pDst, IppiSize imgSize);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc

Pointer to the source image buffer for pixel-order image. An array of pointers to the source image buffer in each color plane for planar image.

srcStep

Distance in bytes between starts of consecutive lines in the source image for operations with ROI. An array of three values in case of planar image.

pDst

Pointer to the destination image buffer for pixel-order image. An array of pointers to the destination image buffers in each color plane for planar image.

dstStep

Distance in bytes between starts of consecutive lines in the destination image for operations with ROI.

roiSize

Size of the source and destination ROI in pixels.

imgSize

Size of the source and destination images in pixels for operations without ROI.

Description

This function converts the Y'U'V' image pSrc to the gamma-corrected R'G'B' image pDst according to the same formulas as the function ippiYUVToRGB does. The difference is that ippiYUV422ToRGB4:2:0 sampling the input data to be in 4:2:2 sampling format (see Table “Pixel-Order Image Formats” and Table “Planar Image Formats” for more details).

The function ippiYUV422ToRGB_P3AC4R additionally creates an alpha channel in the destination image with alpha values set to zero.
Some function flavors operates with ROI (see Regions of Interest in Intel IPP). The function flavors that do not use ROI operate on the assumption that both the source and destination images have the same size and occupy a contiguous memory area, which means that image rows are not padded with zeroes. In this case the step arguments are not needed.

**Return Values**

- **ippStsNoErr**
  - Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**
  - Indicates an error condition if pSrc or pDst is NULL.
- **ippStsSizeErr**
  - Indicates an error condition if roiSize or imgSize has a field with a zero or negative value.

**RGBToYUV420**

Converts an RGB image to the 4:2:0 YUV image.

**Syntax**

**Case 1: Operation on planar data with ROI**

IppStatus ippiRGBToYUV420_8u_P3R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

**Case 2: Operation on planar data without ROI**

IppStatus ippiRGBToYUV420_8u_P3(const Ipp8u* pSrc[3], Ipp8u* pDst[3], IppiSize imgSize);

**Case 3: Conversion from pixel-order to planar data with ROI**

IppStatus ippiRGBToYUV420_8u_C3P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

**Case 4: Conversion from pixel-order to planar data without ROI**

IppStatus ippiRGBToYUV420_8u_C3P3(const Ipp8u* pSrc, Ipp8u* pDst[3], IppiSize imgSize);

**Include Files**

ippcc.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**
  - Pointer to the source image buffer for pixel-order image. An array of pointers to the source image buffers in each color plane for planar image.
- **srcStep**
  - Distance in bytes between starts of consecutive lines in the source image for operations with ROI.
- **pDst**
  - An array of pointers to the destination image buffers in each color plane.
- **dstStep**
  - An array of distances in bytes between starts of consecutive lines in each plane of the destination image for operations with ROI.
roiSize  Size of the source and destination ROI in pixels.
imgSize   Size of the source and destination images in pixels for operations without ROI.

Description
This function converts the gamma-corrected R'G'B' image pSrc to the Y'U'V' image pDst with the 4:2:0 sampling (see Table "Planar Image Formats" for more details). The conversion is performed in the accordance with the same formulas as the functionippiRGBToYUV does.

For digital RGB values in the range [0..255], Y' has the range [0..255], U varies in the range [-112..+112], and V in the range [-157..+157]. To fit in the range of [0..255], a constant value 128 is added to computed U and V values, and V is then saturated.

Some function flavors operates with ROI see Regions of Interest in Intel IPP).

The function flavors that does not use ROI operate on the assumption that both the source and destination images have the same size and occupy a contiguous memory area, which means that image rows are not padded with zeroes. In this case the step parameters are not needed.
roiSize.width (imgSize.width) and roiSize.height (imgSize.height) should be multiples of 2. Otherwise, the function reduces their original values to the nearest multiples of 2, performs operation, and returns warning message.

Return Values
ippStsNoErr  Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr  Indicates an error condition if pSrc or pDst is NULL.
ippStsSizeErr  Indicates an error condition if roiSize or imgSize has a field with a zero or negative value.
ippStsDoubleSize  Indicates a warning if roiSize or imgSize has a field that is not a multiple of 2.

YUV420ToRGB
Converts a YUV image that has 4:2:0 sampling format to the RGB image.

Syntax
Case 1: Operation on planar data with ROI
IppStatus ippiYUV420ToRGB_8u_P3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst[3], int dstStep, IppiSize roiSize);

Case 2: Operation on planar data without ROI
IppStatus ippiYUV420ToRGB_8u_P3(const Ipp8u* pSrc[3], Ipp8u* pDst[3], IppiSize imgSize);

Case 3: Conversion from planar to pixel-order data with ROI
IppStatus ippiYUV420ToRGB_<mod>(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:
8u_P3C3R  8u_P3AC4R
Case 4: Conversion from planar to pixel-order data without ROI

IppStatus ippiYUV420ToRGB_8u_P3C3(const Ipp8u* pSrc[3], Ipp8u* pDst, IppiSize imgSize);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc  An array of pointers to the source image buffers in each color plane.
srcStep An array of distances in bytes between starts of consecutive lines in each source image planes for operations with ROI.
pDst  Pointer to the destination image buffer for pixel-order images. An array of pointers to the destination image buffers in each color plane for planar images.
dstStep Distance in bytes between starts of consecutive lines in the destination image for operations with ROI.
roiSize Size of the source and destination ROI in pixels.
imgSize Size of the source and destination images in pixels for operations without ROI.

Description

This function converts the Y'U'V' image pSrc to the gamma-corrected R'G'B' image pDst according to the same formulas as the function ippiYUVToRGB does. The difference is that ippiYUV420ToRGB4:2:0 sampling the input data to be in 4:2:2 sampling format (see Table "Planar Image Formats" for more details).

The function ippiYUV420ToRGB_P3AC4R additionally creates an alpha channel in the destination image with alpha values set to zero.

Some function flavors operates with ROI see Regions of Interest in Intel IPP).

The function flavors that does not use ROI operate on the assumption that both the source and destination images have the same size and occupy a contiguous memory area, which means that image rows are not padded with zeroes. In this case the step parameters are not needed. roiSize.width(imgSize.width) and roiSize.height(imgSize.height) should be multiples of 2. Otherwise, the function reduces their original values to the nearest multiples of 2, performs operation, and returns warning message.

Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error condition if pSrc or pDst pointer is NULL.
ippStsSizeErr Indicates an error condition if roiSize or imgSize has a field with a zero or negative value.
BGRToYUV420

Converts an BGR image to the YUV color model; uses 4:2:0 sampling

Syntax

IppStatus ippiBGRToYUV420_8u_AC4P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- **pSrc**
  - Pointer to the source image ROI.

- **srcStep**
  - Distance in bytes between starts of consecutive lines in the source image.

- **pDst**
  - An array of pointers to the destination image buffers in each color plane.

- **dstStep**
  - An array of distances in bytes between starts of consecutive lines in each plane of the destination image.

- **roiSize**
  - Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the gamma-corrected B'G'R' image pSrc to the Y'U'V' image pDst with the 4:2:0 sampling (see Table "Planar Image Formats" for more details). The function uses the same formulas as the function ippiRGBToYUV does.

For digital BGR values in the range [0..255], Y' varies in the range [0..255], U - in the range [-112..+112], and V - in the range [-157..+157]. To fit in the range of [0..255], a constant value 128 is added to the computed U and V values, and V is then saturated.

roiSize.width and roiSize.height should be multiples of 2. If not the function reduces their original values to the nearest multiples of 2, performs operation, and returns warning message.

Return Values

- **ippStsNoErr**
  - Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**
  - Indicates an error condition if pSrc or pDst is NULL.

- **ippStsSizeErr**
  - Indicates an error condition if roiSize or imgSize has a field with a zero or negative value.
Indicates a warning if roiSize or imgSize has a field that is not a multiple of 2.

**YUV420ToBGR**

*Converts a YUV image that has 4:2:0 sampling to the BGR image.*

**Syntax**

```c
IppStatus ippiYUV420ToBGR_8u_P3C3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);
```

**Include Files**

ippcc.h

**Domain Dependencies**

*Headers:* ippcore.h, ippvm.h, ipps.h,ippi.h

*Libraries:* ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**: An array of pointers to ROI in each color plane in the source image.
- **srcStep**: An array of distances in bytes between starts of consecutive lines in the source image planes.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**: Size of the source and destination ROI in pixels.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the Y'U'V' image pSrc to the gamma-corrected B'G'R' image pDst according to the same formulas as the function ippiYUVToRGB does. The input data must be presented in the 4:2:0 sampling format (see Table "Planar Image Formats" for more details).

roiSize.width and roiSize.height should be multiples of 2. Otherwise, the function reduces their original values to the nearest multiples of 2, performs operation, and returns warning message.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if pSrc or pDst is NULL.
- **ippStsSizeErr**: Indicates an error condition if roiSize has a field with a zero or negative value.
- **ippStsDoubleSize**: Indicates a warning if roiSize has a field that is not a multiple of 2.
YUV422v210ToRGB, YUV422v210ToBGR

 Converts a YUV422 (v210) image to a RGB/BGR image for ITU-R BT.709 HDTV signal.

Syntax

IppStatus ippiYUV422v210ToRGB_709HDTV_32u16u_C3(const Ipp32u* pSrc, int srcStep, Ipp16u* pDst, int dstStep, IppiSize roiSize);

IppStatus ippiYUV422v210ToBGR_709HDTV_32u16u_C3(const Ipp32u* pSrc, int srcStep, Ipp16u* pDst, int dstStep, IppiSize roiSize);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters

pSrc
Pointer to the source image ROI.

srcStep
Distance, in bytes, between starts of consecutive lines in the source image.

pDst
Pointer to the destination image ROI.

dstStep
Distance, in bytes, between starts of consecutive lines in the destination image.

roiSize
Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the YUV image pSrc, packed in the 4:2:2 sampling format, to the gamma-corrected RGB/BGR image pDst for digital component video signals in compliance with the ITU-R BT.709 Recommendation [ITU709] for high-definition TV (HDTV). The source YUV image has the following sequence of bytes: UYV|YUY|VYU|YVY, ... The conversion is performed according to the following formulas:

\[
\begin{align*}
R &= Y + 1.540*(V - 512) \\
G &= Y - 0.459*(V - 512) - 0.183*(U - 512) \\
B &= Y + 1.816*(U - 512)
\end{align*}
\]

The output RGB/BGR values are saturated to the range R [0..31], G [0..63], B [0..31].

Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr
Indicates an error condition if pSrc or pDst is NULL.

ippStsSizeErr
Indicates an error condition if roiSize has a field with a zero or negative value.
YUV422v210ToGray
Converts a YUV422 (v210) image to a grayscale image for ITU-R BT.709 HDTV signal

Syntax
IppStatus ippiYUV422v210ToGray_709HDTV_32u16u_C3C1(const Ipp32u* pSrc, int srcStep, Ipp16u* pDst, int dstStep, IppiSize roiSize);

Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
pSrc
Pointer to the source image ROI.

srcStep
Distance, in bytes, between starts of consecutive lines in the source image.

pDst
Pointer to the destination image ROI.

dstStep
Distance, in bytes, between starts of consecutive lines in the destination image.

roiSize
Size of the source and destination ROI in pixels.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the YUV image pSrc, packed in the 4:2:2 sampling format, to the grayscale 16U_C1 image pDst for digital component video signals in compliance with the ITU-R BT.709 Recommendation [ITU709] for high-definition TV (HDTV). The source YUV image has the following sequence of bytes: UYV|YUY|VYU|YVY, ... .

Return Values
ippStsNoErr
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr
Indicates an error condition if pSrc or pDst is NULL.

ippStsSizeErr
Indicates an error condition if roiSize has a field with a zero or negative value.

RGBToYCbCr
Converts an RGB image to the YCbCr color model.
Syntax

Case 1: Operation on pixel-order data

IppStatus ippiRGBToYCbCr_<mod>(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

8u_C3R 8u_AC4R

Case 2: Operation on planar data

IppStatus ippiRGBToYCbCr_8u_P3R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst[3], int dstStep, IppiSize roiSize);

Case 3: Conversion from pixel-order to planar data

IppStatus ippiRGBToYCbCr_<mod>(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep, IppiSize roiSize);

Supported values for mod:

8u_C3P3R 8u_AC4P3R

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc  
Pointer to the source image ROI for a pixel-order image. An array of pointers to ROI in each separate source color planes for planar images.

srcStep  
Distance in bytes between starts of consecutive lines in the source image.

pDst  
Pointer to the destination imnage ROI. Array of pointers to ROI in the separate destination color planes for planar images.

dstStep  
Distance in bytes between starts of consecutive lines in the destination image.

roiSize  
Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the gamma-corrected R'G'B' image pSrc with values in the range [0..255] to the Y'Cb'Cr' image pDst according to the following formulas:

\[
\begin{align*}
Y' &= 0.257*R' + 0.504*G' + 0.098*B' + 16 \\
Cb' &= -0.148*R' - 0.291*G' + 0.439*B' + 128 \\
Cr' &= 0.439*R' - 0.368*G' - 0.071*B' + 128
\end{align*}
\]

In the YCbCr model, \( Y \) is defined to have a nominal range [16..235], while \( Cb \) and \( Cr \) are defined to have a range [16..240], with the value of 128 as corresponding to zero.
Both the source and destination images have the same bit depth.

Return Values

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error condition if pSrc or pDst is NULL.
- ippStsSizeErr: Indicates an error condition if roiSize has a field with a zero or negative value.

**YCbCrToRGB**

Converts a YCbCr image to the RGB color model.

Syntax

Case 1: Operation on pixel-order data

```c
IppStatus ippiYCbCrToRGB_<mod>(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
```

Supported values for mod:

- 8u_C3R
- 8u_AC4R

Case 2: Operation on planar data

```c
IppStatus ippiYCbCrToRGB_8u_P3R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst[3], int dstStep, IppiSize roiSize);
IppStatus ippiYCbCrToRGB_8u_P3C3R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
```

Case 3: Conversion from planar to pixel-order data

```c
IppStatus ippiYCbCrToRGB_8u_P3C4R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);
```

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- pSrc: Pointer to the source image ROI for pixel-order image. Array of pointers to the ROI in each separate source color planes for planar images.
- srcStep: Distance in bytes between starts of consecutive lines in the source image.
- pDst: Pointer to the destination image ROI. Array of pointers to the ROI in the separate destination color planes for planar images.
- dstStep: Distance in bytes between starts of consecutive lines in the destination image.
roiSize

Size of the source and destination ROI in pixels.

aval

Constant value to create the fourth channel.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the \( Y'Cb'Cr' \) image \( pSrc \) to the 24-bit gamma-corrected \( R'G'B' \) image \( pDst \). The following formulas are used for conversion:

\[
\begin{align*}
R' &= 1.164 \times (Y' - 16) + 1.596 \times (Cr' - 128) \\
G' &= 1.164 \times (Y' - 16) - 0.813 \times (Cr' - 128) - 0.392 \times (Cb' - 128) \\
B' &= 1.164 \times (Y' - 16) + 2.017 \times (Cb' - 128)
\end{align*}
\]

The output \( R'G'B' \) values are saturated to the range \([0..255]\).

The fourth channel is created by setting channel values to the constant value \( aval \).

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr

Indicates an error condition if \( pSrc \) or \( pDst \) pointer is NULL.

ippStsSizeErr

Indicates an error condition if \( roiSize \) has a field with a zero or negative value.

YCbCrToBGR

Converts a YCbCr image to the BGR color model.

Syntax

IppStatus ippiYCbCrToBGR_8u_P3C3R(const Ipp8u* \( pSrc \)[3], int srcStep, Ipp8u* \( pDst \), int dstStep, IppiSize \( roiSize \));

IppStatus ippiYCbCrToBGR_8u_P3C4R(const Ipp8u* \( pSrc \)[3], int srcStep, Ipp8u* \( pDst \), int dstStep, IppiSize \( roiSize \), Ipp8u \( aval \));

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

\( pSrc \)

An array of pointers to ROI in each separate source color planes.

\( srcStep \)

Distance in bytes between starts of consecutive lines in the source image.

\( pDst \)

Pointer to the destination image ROI.
**dstStep**
Distance in bytes between starts of consecutive destination lines in the
destination image.

**roiSize**
Size of the source and destination ROI in pixels.

**aval**
Constant value to create the fourth channel.

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the Y'Cb'Cr' image pSrc to the 24-bit gamma-corrected B'G'R' image pDst
according to the same formulas as the functionippiYCbCrToRGB does. The output B'G'R' values are
saturated to the range [0..255].
The fourth channel is created by setting channel values to the constant value aval.

**Return Values**
- ippStsNoErr
  Indicates no error. Any other value indicates an error or a
  warning.
- ippStsNullPtrErr
  Indicates an error condition if pSrc or pDst is NULL.
- ippStsSizeErr
  Indicates an error condition if roiSize.width is less than 4 or
  roiSize.height is less than 1.

**YCbCrToBGR_709CSC**
Converts a YCbCr image to the BGR image for ITU-R
BT.709 CSC signal.

**Syntax**

```c
IppStatus ippiYCbCrToBGR_709CSC_8u_P3C3R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiYCbCrToBGR_709CSC_8u_P3C4R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);
```

**Include Files**

ippcc.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**
  An array of pointers to ROI in separate planes of the source image.

- **srcStep**
  An array of distances in bytes between starts of consecutive
  lines in the source image planes.

- **pDst**
  Pointer to the destination image ROI.

- **dstStep**
  Distance in bytes between starts of consecutive lines in the
  destination image.
roiSize

Size of the source and destination ROI in pixels.

aval

Constant value to create fourth channel.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts a planar \( Y'Cb'Cr' \) image \( pSrc \) to the three- or four-channel gamma-corrected B'G'R' image \( pDst \) for digital component video signals complied with the ITU-R BT.709 Recommendation [ITU709] for computer systems consideration (CSC). The conversion is performed according to the following formulas [Jack01]:

\[
R' = 1.164*(Y' - 16) + 1.793*(Cr' - 128) \\
G' = 1.164*(Y' - 16) - 0.534*(Cr' - 128) - 0.213*(Cb' - 128) \\
B' = 1.164*(Y' - 16) + 2.115*(Cb' - 128)
\]

The output \( R'G'B' \) values are saturated to the range \([0..255]\).

The fourth channel is created by setting channel values to the constant value \( aval \).

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr

Indicates an error condition if \( pSrc \) or \( pDst \) is NULL.

ippStsSizeErr

Indicates an error condition if \( roiSize \) has a field with a zero or negative value.

RGBToYCbCr422

Converts an RGB image to the \( YCbCr \) image with 4:2:2 sampling.

Syntax

Case 1: Operation on pixel-order data

IppStatus ippiRGBToYCbCr422_8u_C3C2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);

Case 2: Conversion from pixel-order to planar data

IppStatus ippiRGBToYCbCr422_8u_C3P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

Case 2: Conversion from planar to pixel-order data

IppStatus ippiRGBToYCbCr422_8u_P3C2R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Parameters

- `pSrc`: Pointer to the source image ROI for pixel-order image. An array of pointers to ROI in each separate source color planes for planar images.
- `srcStep`: Distance in bytes between starts of consecutive lines in the source image.
- `pDst`: Pointer to the destination image ROI for pixel-order image. An array of pointer to ROI in each separate planes for the planar destination image.
- `dstStep`: Distance in bytes between starts of consecutive lines in the destination image.
- `roiSize`: Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP). This function converts the gamma-corrected R'G'B' image `pSrc` to the Y'Cb'Cr' image `pDst` with 4:2:2 sampling (see Table "Pixel-Order Image Formats" and Table "Planar Image Formats" for more details). The conversion is performed according to the same formulas as the function `ippiRGBToYCbCr` does.

The converted buffer for pixel-order image has the reduced bit depth of a 16 bits per pixel, whereas the source buffer has 24 bit depth.

Return Values

- `ippStsNoErr`: Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr`: Indicates an error condition if `pSrc` or `pDst` is NULL.
- `ippStsSizeErr`: Indicates an error condition if `roiSize` has a field with a zero or negative value.

**YCbCr422ToRGB**

Converts an YCbCr image with the 4:2:2 sampling to the RGB image.

Syntax

Case 1: Operation on pixel-order data

```c
IppStatusippiYCbCr422ToRGB_8u_C2C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatusippiYCbCr422ToRGB_8u_C2C4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);
```

Case 2: Conversion from pixel-order to planar data

```c
IppStatusippiYCbCr422ToRGB_8u_C2P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep, IppiSize roiSize);
```

Case 3: Conversion from planar to pixel-order data

```c
IppStatusippiYCbCr422ToRGB_8u_P3C3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);
```
Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc  
Pointer to the source image ROI for pixel-order image. An array of pointers to ROI in each separate source planes for planar images.

srcStep  
Distance, in bytes, between the starting points of consecutive lines in the source image.

pDst  
Pointer to the ROI in the destination pixel-order image. An array of pointers to ROI in each planes of the destination planar image.

dstStep  
Distance, in bytes, between the starting points of consecutive lines in the destination image.

roiSize  
Size of the source and destination ROI in pixels.

aval  
Constant value to create the fourth channel.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the Y'Cb'Cr' image pSrc with the 4:2:2 sampling (see Table "Pixel-Order Image Formats" and Table "Planar Image Formats" for more details) to the gamma-corrected R'G'B' image pDst according to the same formulas as the function ippiYCbCrToRGB does. The output R'G'B' values are saturated to the range [0..255].

Return Values

ippStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  
Indicates an error condition if pSrc or pDst is NULL.

ippStsSizeErr  
Indicates an error condition if roiSize has a field with a zero or negative value.

Example
The code example below demonstrates how to use the ippiYCbCr422ToRGB_8u_C2C4R function.

```c
const int WIDTH = 2;
const int HEIGHT = 2;

Ipp8u pSrc[WIDTH * HEIGHT * 2] =
{    
236,50,236,80,
    236,50,236,80,
};
Ipp8u pDstRGB[(WIDTH * HEIGHT) * 4];
int srcStep = WIDTH * 2, dstStep = WIDTH * 4;
IppiSize roiSize = {WIDTH, HEIGHT};
```
Ipp8u alphaValue = 0xFF;
IppStatus status = ippiYCbCr422ToRGB_8u_C2C4R(pSrc, srcStep, pDstRGB, dstStep, roiSize, alphaValue);
if (status == ippStsNoErr)
    printf("\n **************** passed ****************\n");
else
    printf("\n **************** failed ****************\n");

RGBToYCrCb422
Converts 24-bit per pixel RGB image to 16-bit per pixel YCrCb image

Syntax
Case 1: Operation on pixel-order data
IppStatus ippiRGBToYCrCb422_8u_C3C2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
Case 2: Conversion from planar to pixel-order data
IppStatus ippiRGBToYCrCb422_8u_P3C2R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);

Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters

pSrc

srcStep

pDst
dstStep

roiSize

Description
This function operates with ROI (see Regions of Interest in Intel IPP). This function converts the gamma-corrected R'G'B' image \( pSrc \) to the Y'Cb'Cr' image \( pDst \) according to the same formulas as the function ippiRGBToYCbCcrippiRGBToYCbCr does. The difference is that ippiRGBToYCrCb422 uses 4:2:2 sampling format for the converted image (see Table “Pixel-Order Image Formats” and Table “Planar Image Formats” for more details).

The converted buffer has the reduced bit depth of 16 bits per pixel, whereas the source buffer has 24 bit depth.
Return Values

ippStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  
Indicates an error condition if pSrc or pDst is NULL.

ippStsSizeErr  
Indicates an error condition if roiSize has a field with a zero or negative value.

YCrcb422ToRGB, YCrcb422ToBGR

Convert 16-bit per pixel YCrcb image to 24 or 32-bit per pixel RGB or BGR image.

Syntax

Case 1: Operation on pixel-order data

IppStatusippiYCrCb422ToRGB_8u_C2C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatusippiYCrCb422ToRGB_8u_C2C4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);
IppStatusippiYCrCb422ToBGR_8u_C2C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatusippiYCrCb422ToBGR_8u_C2C4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);

Case 2: Conversion from pixel-order to planar data

IppStatusippiYCrCb422ToRGB_8u_C2P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep, IppiSize roiSize);

Include Files

ippc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters

pSrc  
Pointer to the source image ROI for pixel-order image. An array of pointers to ROI in each separate source plane for planar images.

srcStep  
Distance, in bytes, between the starting points of consecutive lines in the source image.

pDst  
Pointer to the ROI in the destination pixel-order image. An array of pointers to ROI in each plane of the destination planar image.

dstStep  
Distance, in bytes, between the starting points of consecutive lines in the destination image.

roiSize  
Size of the source and destination ROI in pixels.
aval

Constant value to create the fourth channel.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the Y'Cr'Cb' image pSrc, packed in 4:2:2 sampling format (see Table "Pixel-Order Image Formats" and Table "Planar Image Formats" for more details) to the 24-bit gamma-corrected R'G'B' or B'G'R' image pDst according to the same formulas as the function ippiYCbCrToRGB does. The output R'G'B' values are saturated to the range [0..255]. Y'Cr'Cb' image with 4:2:2 sampling is also known as YVYU format.

Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error condition if pSrc or pDst is NULL.
ippStsSizeErr Indicates an error condition if roiSize has a field with a zero or negative value.

Example

The code example below demonstrates how to use the ippiYCrCb422ToRGB_8u_C2C4R function.

```c
#define WIDTH 2
#define HEIGHT 2

Ipp8u pSrc[WIDTH * HEIGHT * 2] =
{
    236,50,236,80,
    236,50,236,80,
};
Ipp8u pDstRGB[(WIDTH * HEIGHT) * 4];
int srcStep = WIDTH * 2, dstStep = WIDTH * 4;
IppiSize roiSize = {WIDTH, HEIGHT};
Ipp8u alphaValue = 0xFF;
IppStatus status = ippiYCrCb422ToRGB_8u_C2C4R(pSrc, srcStep, pDstRGB, dstStep, roiSize, alphaValue);
if (status == ippStsNoErr)
    printf("\n *************  passed ****************\n");
else
    printf("\n *************  failed ****************\n");
```

BGRToYCbCr422

Converts 24-bit per pixel BGR image to 16-bit per pixel YCbCr image.

Syntax

Case 1: Operation on pixel-order data

IppStatus ippiBGRToYCbCr422_8u_C3C2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiBGRToYCbCr422_8u_AC4C2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
Case 2: Conversion from pixel-order to planar data

IppStatus ippiBGRToYCbCr422_8u_C3P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppSize roiSize);

IppStatus ippiBGRToYCbCr422_8u AC4P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppSize roiSize);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc Pointer to the source mage ROI.
srcStep Distance in bytes between starts of consecutive lines in the source image.
pDst Pointer to the ROI in the destination pixel-order image. An array of pointers to ROI in each planes of the destination planar image.
dstStep Distance in bytes between starts of consecutive lines in the destination pixel-order image. An array of distances in bytes for each plane of the destination planar image.
roiSize Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts a three- or four-channel gamma-corrected B'G'R' image pSrc to the two-channel or three-planes Y'Cb'Cr' image pDst according to the same formulas as the function ippiRGBToYCbCr does. The difference is that ippiBGRToYCbCr422 uses the 4:2:2 sampling format (see Table "Pixel-Order Image Formats" and Table "Planar Image Formats" for more details).

Return Values

IppStsNoErr Indicates no error. Any other value indicates an error or a warning.
IppStsNullPtrErr Indicates an error condition if pSrc or pDst is NULL.
IppStsSizeErr Indicates an error condition if roiSize.width is less than 2 or roiSize.height is less than 1.

YCbCr422ToBGR

Converts a YCbCr image with 4:2:2 sampling to the BGR image.
Syntax

Case 1: Operation on pixel-order data

IppStatus ippiYCbCr422ToBGR_8u_C2C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);

IppStatus ippiYCbCr422ToBGR_8u_C2C4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);

Case 2: Conversion from planar to pixel-order data

IppStatus ippiYCbCr422ToBGR_8u_P3C3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc

Pointer to the source image ROI. An array of pointers to the ROI in each separate plane of the source planar image.

srcStep

Distance in bytes between starts of consecutive lines in the source image. An array of such distances in bytes for each plane of the source planar image.

pDst

Pointer to the destination image ROI.

dstStep

Distance in bytes between starts of consecutive lines in the destination image.

roiSize

Size of the source and destination ROI in pixels.

aval

Constant value to create the fourth channel.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the Y'Cb'Cr' image pSrc with 4:2:2 sampling (see Table "Pixel-Order Image Formats" and Table "Planar Image Formats" for more details) to the gamma-corrected B'G'R' image pDst according to the same formulas as the functionippiYCbCrToRGB does.

The output B'G'R' values are saturated to the range [0..255].

The fourth channel is created by setting channel values to the constant value aval.

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr

Indicates an error condition if pSrc or pDst is NULL.

ippStsSizeErr

Indicates an error condition if roiSize.width is less than 2 or roiSize.height is less than 1.
YCbCr422ToGray

Converts an interlaced 4:2:2 YCbCr or YCrCb image to gray-scale extracting luminance (Y) component.

Syntax

IppStatus ippiYCbCr422ToGray_8u_C2C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc

Pointer to the source image ROI.

srcStep

Distance, in bytes, between the starting points of consecutive lines in the source image.

pDst

Pointer to the destination image ROI.

dstStep

Distance, in bytes, between the starting points of consecutive lines in the destination image.

roiSize

Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts an interlaced Y'Cb'Cr' or Y'Cr'Cb' image pSrc with the 4:2:2 sampling (see Table “Pixel-Order Image Formats” and Table “Planar Image Formats” for more details) to the gray-scale image pDst extracting luminance (Y) component.

Y'Cb'Cr' image with 4:2:2 sampling is also known as YUY2 format, and Y'Cr'Cb' as YVYU.

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr

Indicates an error condition if pSrc or pDst is NULL.

ippStsSizeErr

Indicates an error condition if roiSize has a field with a zero or negative value.

Example

The code example below demonstrates how to use the ippiYCbCr422ToGray_8u_C2C1R function.

```c
const int WIDTH = 2;
const int HEIGHT = 2;
Ipp8u pSrc[WIDTH * HEIGHT * 2] = {
    190,70,191,80,
```
IPP8u pDst[WIDTH * HEIGHT];
int srcStep = WIDTH * 2, dstStep = WIDTH;
IppiSize roiSize = {WIDTH, HEIGHT};
IppStatus status = ippiYCbCr422ToGray_8u_C2C1R(pSrc, srcStep, pDst, dstStep, roiSize);
if (status == ippStsNoErr)
    printf("PASS:
%3d %3d
%3d %3d
", pDst[0], pDst[1], pDst[2], pDst[3]);
else
    printf("FAIL: status = %d\n", status);

Result:
PASS:
190 191
200 201

**RGBToCbYCr422, RGBToCbYCr422Gamma**

*Convert 24-bit per pixel RGB image to 16-bit per pixel CbYCr image.*

**Syntax**

IppStatus ippiRGBToCbYCr422_8u_C3C2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);

IppStatus ippiRGBToCbYCr422Gamma_8u_C3C2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);

**Include Files**

ippcc.h

**Domain Dependencies**

*Headers:* ippcore.h, ippvm.h, ipps.h,ippi.h

*Libraries:* ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**
  - Pointer to the source image ROI.

- **srcStep**
  - Distance in bytes between starts of consecutive lines in the source image.

- **pDst**
  - Pointer to the destination image ROI.

- **dstStep**
  - Distance in bytes between starts of consecutive lines in the destination image.

- **roiSize**
  - Size of the source and destination ROI in pixels.

**Description**

These functions operate with ROI (see Regions of Interest in Intel IPP).

The function `ippiRGBToCbYCr422` converts the gamma-corrected R'G'B' image `pSrc` to the Cb'Y'Cr' image `pDst` according to the same formulas as the function `ippiRGBToYCbCr` does.
The function `ippiRGBToCbYCr422Gamma` performs gamma-correction of the source RGB image `pSrc` according to the same formula as the function `ippiGammaFwd` does, and then converts it to the Cb'Y'Cr' image `pDst` according to the same formulas as the function `ippiRGBToYCbCr` does.

The functions `ippiRGBToCbYCr422` and `ippiRGBToCbYCr422Gamma` use 4:2:2 sampling format for the converted image.

A CbYCr image has the following sequence of bytes: Cb0Y0Cr0Y1, Cb1Y2Cr1Y3, ....

**Return Values**

- `ippStsNoErr` Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr` Indicates an error condition if `pSrc` or `pDst` is NULL.
- `ippStsSizeErr` Indicates an error condition if `roiSize` has a field with a zero or negative value.

**CbYCr422ToRGB**

*Converts 16-bit per pixel CbYCr image to 24-bit per pixel RGB image.*

**Syntax**

```c
IppStatus ippiCbYCr422ToRGB_8u_C2C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
```

**Include Files**

```c
ippcc.h
```

**Domain Dependencies**

- **Headers**: ippcore.h, ippvm.h, ipps.h,ippi.h
- **Libraries**: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc** Pointer to the source image ROI.
- **srcStep** Distance in bytes between starts of consecutive lines in the source image.
- **pDst** Pointer to the destination image ROI.
- **dstStep** Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize** Size of the source and destination ROI in pixels

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the Cb'Y'Cr' image `pSrc`, packed in the 4:2:2 sampling format, to the 24-bit gamma-corrected R'G'B' image `pDst` according to the same formulas as the function `ippiYCbCrToRGB` does.

A CbYCr image has the following sequence of bytes: Cb0Y0Cr0Y1, Cb1Y2Cr1Y3, ....

The output R'G'B' values are saturated to the range [0..255].
Return Values

ippStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  
Indicates an error condition if pSrc or pDst is NULL.

ippStsSizeErr  
Indicates an error condition if roiSize has a field with a zero or negative value.

BGRToCbYCr422

Converts 32-bit per pixel BGR image to 16-bit per pixel CbYCr image.

Syntax

IppStatus ippiBGRToCbYCr422_8u_AC4C2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc  
Pointer to the source image ROI.

csrcStep  
Distance in bytes between starts of consecutive lines in the source image.

pDst  
Pointer to the destination image ROI.

dstStep  
Distance in bytes between starts of consecutive lines in the destination image.

roiSize  
Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the four-channel gamma-corrected B'G'R' image pSrc to the two-channel Cb'Y'Cr' image pDst according to the same formulas as the function ippiRGBToYCbCr does. The function ippiBGRToCbYCr422 uses 4:2:2 sampling format for the converted image. An alpha-channel information is lost.

An CbYCr image has the following sequence of bytes: Cb0Y0Cr0Y1, Cb1Y2Cr1Y3, ...

Return Values

ippStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  
Indicates an error condition if pSrc or pDst is NULL.
ippStsSizeErr indicates an error condition if roiSize has a field with a zero or negative value.

**BGRToCbYCr422_709HDTV**

Converts BGR image to 16-bit per pixel CbYCr image for ITU-R BT.709 HDTV signal.

**Syntax**

IppStatus ippiBGRToCbYCr422_709HDTV_8u_C3C2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppSize roiSize);
IppStatus ippiBGRToCbYCr422_709HDTV_8u_AC4C2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppSize roiSize);

**Include Files**

ippcc.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**
  Pointer to the source image ROI.
- **srcStep**
  Distance in bytes between starts of consecutive lines in the source image.
- **pDst**
  Pointer to the destination image ROI.
- **dstStep**
  Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**
  Size of the source and destination ROI in pixels.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the three- or four-channel gamma-corrected B’G’R’ image pSrc to the two-channel Cb’Y’Cr’ image pDst for digital component video signals complied with the ITU-R BT.709 Recommendation [ITU709] for high-definition TV (HDTV). The source image pixel values are in the range [16..235]. The conversion is performed according to the following formulas [Jack01]:

\[
Y' = 0.213*R' + 0.715*G' + 0.072*B'
\]

\[
Cb' = -0.117*R' - 0.394*G' + 0.511*B' + 128
\]

\[
Cr' = 0.511*R' - 0.464*G' - 0.047*B' + 128
\]

The values of \( Y' \) of the destination image are in the range [16..235], the values of \( Cb', Cr' \) are in the range [16..240]. They should be saturated at the 1 and 254 levels.

The function ippiBGRToCbYCr422_709HDTV uses the 4:2:2 sampling format for the converted image. The alpha-channel information is lost.

A CbYCr image has the following sequence of bytes: Cb0Y0Cr0Y1, Cb1Y2Cr1Y3, ...
Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if `pSrc` or `pDst` pointer is `NULL`.
- **ippStsSizeErr**: Indicates an error condition if `roiSize` has a field with a zero or negative value.

**CbYCr422ToBGR**

*Converts 16-bit per pixel CbYCr image to four channel BGR image.*

**Syntax**

```c
IppStatus ippiCbYCr422ToBGR_8u_C2C4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);
```

**Include Files**

ippcc.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**: Size of the source and destination ROI in pixels.
- **aval**: Constant value to create the fourth channel.

**Description**

This function operates with ROI (see **Regions of Interest in Intel IPP**).

This function converts the Cb'Y'Cr' image `pSrc`, packed in 4:2:2 sampling format, to the four channel gamma-corrected B'G'R' image `pDst` according to the same formulas as the function `ippiYCrCbToRGB` does.

A CbYCr image has the following sequence of bytes: Cb0Y0Cr0Y1, Cb1Y2Cr1Y3, ... .

The output B'G'R' values are saturated to the range [0..255].

The fourth channel is created by setting channel values to the constant value `aval`.

Image Color Conversion
Return Values

ippStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  
Indicates an error condition if pSrc or pDst is NULL.

ippStsSizeErr  
Indicates an error condition if roiSize has a field with a zero or negative value.

CbYCr422ToBGR_709HDTV
Converts 16-bit per pixel CbYCr image to the BGR image for ITU-R BT.709 HDTV signal.

Syntax

IppStatus ippiCbYCr422ToBGR_709HDTV_8u_C2C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiCbYCr422ToBGR_709HDTV_8u_C2C4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc  
Pointer to the source image ROI.

srcStep  
Distance in bytes between starts of consecutive lines in the source image.

pDst  
Pointer to the destination image ROI.

dstStep  
Distance in bytes between starts of consecutive lines in the destination image.

roiSize  
Size of the source and destination ROI in pixels.

aval  
Constant value to create the fourth channel.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the Cb'Y'Cr' image pSrc, packed in 4:2:2 sampling format, to the three- or four-channel gamma-corrected B'G'R' image pDst for digital component video signals complied with the ITU-R BT.709 Recommendation [ITU709] for high-definition TV (HDTV). A source CbYCr image has the following sequence of bytes: Cb0Y0Cr0Y1, Cb1Y2Cr1Y3, ... . The values of Y' are in the range [16..235], the values of Cb', Cr' are in the range [16..240]. The conversion is performed according to the following formulas [Jack01]:

\[
R' = Y' + 1.540 \times (C' - 128)
\]

\[
G' = Y' - 0.459 \times (C' - 128) - 0.183 \times (C' - 128)
\]
\[ B' = Y' + 1.816 \times (C_b' - 128) \]

The destination image pixel values have a nominal range [16..235]. The resulting \( R'G'B' \) values should be saturated at the 0 and 255 levels.

The output \( B'G'R' \) values are saturated to the range [0..255].

The fourth channel is created by setting channel values to the constant value \( a_{val} \).

**Return Values**

- **ippStsNoErr**
  - Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**
  - Indicates an error condition if \( p\text{Src} \) or \( p\text{Dst} \) is NULL.
- **ippStsSizeErr**
  - Indicates an error condition if \( ro\text{iSize} \) has a field with a zero or negative value.

**RGBToYCbCr420**

*Converts an RGB image to the YCbCr color model; uses 4:2:0 sampling.*

**Syntax**

```c
IppStatus ippiRGBToYCbCr420_8u_C3P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiiSize);
IppStatus ippiRGBToYCbCr420_8u_C3P2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDstY, int dstYStep, Ipp8u* pDstCbCr, int dstCbCrStep, IppiSize roiiSize);
IppStatus ippiRGBToYCbCr420_8u_C4P2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDstY, int dstYStep, Ipp8u* pDstCbCr, int dstCbCrStep, IppiSize roiiSize);
```

**Include Files**

ippcc.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**
  - Pointer to the source image ROI.
- **srcStep**
  - Distance in bytes between starts of consecutive lines in the source image.
- **pDst**
  - An array of pointers to ROI in the separate planes of the destination image for three-plane image.
- **dstStep**
  - Array of distances in bytes between starts of consecutive lines in each plane of the destination image for three-plane image.
- **pDstY**
  - Pointer to ROI in the luminance plane of the destination image for two-plane image.
- **dstStep, dstYStep**
  - Distance in bytes between starts of consecutive lines in the luminance plane for two-plane image.
pDstCbCr

dstCbCrStep

roiSize

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the gamma-corrected R'G'B' image `pSrc` to the Y'Cb'Cr' image according to the same formulas as the function `ippiRGBToYCbCr` does. The difference is that `ippiRGBToYCbCr420` uses 4:2:0 sampling format for the converted image (see Table "Planar Image Formats" for more details).

`roiSize.width` should be multiple of 2, and `roiSize.height` should be multiple of 2 (for three-plane image) or 4 (for two-plane image). If not the function reduces their original values to the nearest multiples of 2 or 4 correspondingly, performs operation, and returns warning message.

**Return Values**

- **ippStsNoErr**
  
  Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**
  
  Indicates an error condition if `pSrc` or `pDst` is NULL.

- **ippStsSizeErr**
  
  Indicates an error condition if `roiSize` has a field with value less than 2.

- **ippStsDoubleSize**
  
  Indicates a warning if `roiSize.width` is not a multiple of 2, or if `roiSize.height` is not a multiple of 2 (for three-plane image) or 4 (for two-plane image).

**YCbCr420ToRGB, YCbCr420ToBGR**

Convert a YCbCr image that has 4:2:0 sampling format to the RGB or BGR color model.

**Syntax**

```c
IppStatus ippiYCbCr420ToRGB_8u_P3C3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiYCbCr420ToRGB_8u_P2C3R(const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiYCbCr420ToBGR_8u_P2C3R(const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);
IppStatus ippiYCbCr420ToBGR_8u_P2C4R(const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);
```

**Include Files**

ippcc.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters

**pSrc**
An array of pointers to ROI in separate planes of the three-plane source image.

**srcStep**
An array of distances in bytes between starts of consecutive lines in each plane of the three-plane source image.

**pSrcY**
Pointer to ROI in the luminance plane of the two-plane source image.

**srcYStep**
Distance in bytes between starts of consecutive lines in the luminance plane of the two-plane source image.

**pSrcCbCr**
Pointer to ROI in the interleaved chrominance plane of the two-plane source image.

**srcCbCrStep**
Distance in bytes between starts of consecutive lines in the interleaved chrominance plane of the two-plane source image.

**pDst**
Pointer to the destination image ROI.

**dstStep**
Distance in bytes between starts of consecutive lines in the destination image.

**roiSize**
Size of the source and destination ROI in pixels.

**aval**
Constant value to create the fourth channel.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the Y'Cb'Cr' image **pSrc** to the gamma-corrected R'G'B' or B'G'R' image **pDst** according to the same formulas as the function ippiYCbCrToRGB does. The difference is that the ippiYCbCr420ToRGB and ippiYCbCr420ToBGR functions use the input data in the 4:2:0 sampling format, in which the number of Cb and Cr samples is reduced by half in both vertical and horizontal directions (see Table "Planar Image Formats" for more details). Two-plane Y'Cb'Cr' image with 4:2:0 sampling is also known as NV12 format.

The value of **roiSize.width** and **roiSize.height** must be a multiple of 2. Otherwise, the function reduces original values to the nearest multiples of 2, performs operation, and returns a warning message.

Return Values

**ippStsNoErr**
Indicates no error. Any other value indicates an error or a warning.

**ippStsNullPtrErr**
Indicates an error condition if **pSrc** or **pDst** is NULL.

**ippStsSizeErr**
Indicates an error condition if **roiSize** has a field with value less than 2.

**ippStsDoubleSize**
Indicates a warning if **roiSize** has a field that is not a multiple of 2.

Example

The code example below demonstrates how to use the ippiYCbCr420ToRGB_8u_P2C4R function.

```c
#define WIDTH 4
#define HEIGHT 4
Ipp8u pSrcY[WIDTH * HEIGHT] =
```
RGBToYCrCb420

Converts an RGB image to the YCrCb image with 4:2:0 sampling format.

Syntax

IppStatusippiRGBToYCrCb420_8u_AC4P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3],
int dstStep[3], IppiSize roiSize);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc

Pointer to the source image ROI.

srcStep

Distance in bytes between starts of consecutive lines in the source image.

pDst

Array of pointers to ROI in separate planes of the destination image.

dstStep

Array of distances in bytes between starts of consecutive lines in the destination image planes.

roiSize

Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts a four-channel gamma-corrected R'G'B' image \( pSrc \) to the planar Y'Cr'Cb' image \( pDst \) with the 4:2:0 sampling (see Table "Planar Image Formats" for more details). The conversion is performed according to the same formulas as the function \( \text{ippiRGBToYCbCr} \) does.

\( \text{roiSize.width} \) and \( \text{roiSize.height} \) should be multiples of 2. If not the function reduces their original values to the nearest multiples of 2, performs the operation, and returns a warning message.

### Return Values

- **ippStsNoErr**
  - Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**
  - Indicates an error condition if \( pSrc \) or \( pDst \) is NULL.
- **ippStsSizeErr**
  - Indicates an error condition if \( \text{roiSize} \) has a field with a zero or negative value.
- **ippStsDoubleSize**
  - Indicates a warning if \( \text{roiSize} \) has a field that is not a multiple of 2.

### YCrCb420ToRGB, YCrCb420ToBGR

**Convert a YCrCb image with the 4:2:0 sampling to the RGB or BGR image.**

### Syntax

- \[
\text{IppStatus ippiYCrCb420ToRGB}_8u_P3C4R (const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);
\]
- \[
\text{IppStatus ippiYCrCb420ToRGB}_8u_P2C4R (const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCrCb, int srcCrCbStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);
\]
- \[
\text{IppStatus ippiYCrCb420ToRGB}_8u_P2C3R (const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCrCb, int srcCrCbStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
\]
- \[
\text{IppStatus ippiYCrCb420ToBGR}_8u_P2C3R (const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCrCb, int srcCrCbStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
\]
- \[
\text{IppStatus ippiYCrCb420ToBGR}_8u_P2C4R (const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCrCb, int srcCrCbStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);
\]
- \[
\text{IppStatus ippiYCrCb420ToBGR}_8u_F2C4R (const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCrCb, int srcCrCbStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);
\]
- \[
\text{IppStatus ippiYCrCb420ToBGR}_8u_F2C3R (const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCrCb, int srcCrCbStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
\]
- \[
\text{IppStatus ippiYCrCb420ToBGR}_8u_F2C4R (const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCrCb, int srcCrCbStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);
\]
- \[
\text{IppStatus ippiYCrCb420ToBGR}_8u_F2C3R (const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCrCb, int srcCrCbStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
\]

### Include Files

- ippcc.h

### Domain Dependencies

**Headers**: ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries**: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

### Parameters

- \( pSrc \) An array of pointers to ROI in separate planes of the three-plane source image.
An array of distances, in bytes, between the starting points of consecutive lines in each plane of the three-plane source image.

Pointer to ROI in the luminance plane of the two-plane source image.

Distance, in bytes, between the starting points of consecutive lines in the luminance plane of the two-plane source image.

Pointer to ROI in the interleaved plane chrominance plane of the two-plane source image.

Distance, in bytes, between the starting points of consecutive lines in the interleaved chrominance plane of the two-plane source image.

Pointer to the destination image ROI.

Distance, in bytes, between the starting points of consecutive lines in the destination image.

Size of the source and destination ROI, in pixels.

Constant value to create the fourth channel.

**Description**

This function operates with ROI.

This function converts the Y'Cr'Cb image `pSrc` to the gamma-corrected R'G'B' or B'G'R' image `pDst` according to the same formulas as the `ippiippiYCbCrToRGB` function does. The difference is that the `ippiYCrCb420ToRGB` and `ippiYCrCb420ToBGR` functions use the source data in the 4:2:0 sampling format, in which the number of Cb and Cr samples is reduced by half in both vertical and horizontal directions (see Table "Planar Image Formats" for more details). Two-plane Y'Cr'Cb image with 4:2:0 sampling is also known as NV21 format.

The value of `roiSize.width` and `roiSize.height` must be a multiple of 2. Otherwise, the function reduces original values of `roiSize.width` and `roiSize.height` to the nearest multiples of 2, performs operation, and returns a warning.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when `pSrc` or `pDst` is NULL.
- **ippStsSizeErr**: Indicates an error when `roiSize` has a field with a value less than 2.
- **ippStsDoubleSize**: Indicates a warning if `roiSize` has a field that is not a multiple of 2.

**Example**

The code example below demonstrates how to use the `ippiYCrCb420ToRGB_8u_P2C4R` function.

```c
static void sampleNV21ToRGBA()
{
    Ipp8u pY[4*4] =
    {
        236,236,236,236,
        236,236,236,236,
```
236,236,236,236,
236,236,236,236
};
Ipp8u pCbCr[4*2]=
{
    128,128,128,128,
    128,128,128,128
};
Ipp8u pRGB[(4*4)*4];
int YStep = 4, CbCrStep = 4, rgbStep = 4*4;
IppiSize roiSize = {4,4};
Ipp8u alpha = 0xFF;
IppStatus status = ippiYCrCb420ToRGB_8u_P2C4R(pY, YStep, pCbCr, CbCrStep, pRGB, rgbStep,
roiSize, alpha);
if ( status == ippStsNoErr)
    printf("\n **************** passed ****************\n");
else
    printf("\n **************** failed ****************\t");

See Also
Regions of Interest in Intel IPP

BGRToYCbCr420
Converts a BGR image to the YCbCr image with 4:2:0 sampling format.

Syntax
IppStatus ippiBGRToYCbCr420_8u_C3P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3],
int dstStep[3], IppiSize roiSize);
IppStatus ippiBGRToYCbCr420_8u_C3P2R(const Ipp8u* pRGB, int rgbStep, Ipp8u* pY, int
yStep, Ipp8u* pCbCr, int cbCrStep, IppiSize roiSize);
IppStatus ippiBGRToYCbCr420_8u_AC4P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3],
int dstStep[3], IppiSize roiSize);
IppStatus ippiBGRToYCbCr420_8u_AC4P2R(const Ipp8u* pRGB, int rgbStep, Ipp8u* pY, int
yStep, Ipp8u* pCbCr, int cbCrStep, IppiSize roiSize);

Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters
pSrc, pRGB
    Pointer to the source image ROI.
pY
    Pointer to the image Y plane.
srcStep, rgbStep
    Distance, in bytes, between the starting points of consecutive lines in the source image.
**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts a three- or four-channel gamma-corrected B'G'R' image to the planar Y'Cb'Cr' image according to the same formulas as the function ippiRGBToYCbCr does. The difference is that ippiBGRToYCbCr420 uses 4:2:0 sampling format (see Table “Planar Image Formats” for more details). 

roiSize.width and roiSize.height should be multiples of 2. If not the function reduces their original values to the nearest multiples of 2, performs operation, and returns warning message.

**Return Values**

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr Indicates an error condition if pSrc (pRGB) or pDst (pCbCr) is NULL.

ippStsSizeErr Indicates an error condition if roiSize.width is less than 2 or roiSize.height is less than 2.

ippStsDoubleSize Indicates a warning if roiSize has a field that is not a multiple of 2.

**BGRToYCbCr420_709CSC**

*Converts a BGR image to the YCbCr image with 4:2:0 sampling for ITU-R BT.709 CSC signal.*

**Syntax**

IppStatus ippiBGRToYCbCr420_709CSC_8u_C3P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

IppStatus ippiBGRToYCbCr420_709CSC_8u_C3P2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDstY, int dstYStep, Ipp8u* pDstCbCr, int dstCbCrStep, IppiSize roiSize);

IppStatus ippiBGRToYCbCr420_709CSC_8u_AC4P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

IppStatus ippiBGRToYCbCr420_709CSC_8u_AC4P2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDstY, int dstYStep, Ipp8u* pDstCbCr, int dstCbCrStep, IppiSize roiSize);

**Include Files**

ippcc.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib
Parameters

pSrc

Pointer to the source image ROI.

srcStep

Distance in bytes between starts of consecutive lines in the source image.

pDst, pDstY, pDstCbCr

An array of pointers to ROI in separate planes of the destination image.

dstStep, dstYStep, dstCbCrStep

An array of distances in bytes between starts of consecutive lines in the destination image planes.

roiSize

Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts a three- or four-channel gamma-corrected B'G'R' image pSrc to the planar Y'Cb'Cr' image pDst for digital component video signals complied with the ITU-R BT.709 Recommendation [ITU709] for computer systems consideration (CSC). The source image pixel values are in the range [0..255]. The conversion is performed according to the following formulas [Jack01]:

\[
Y' = 0.183*R' + 0.614*G' + 0.062*B' + 16
\]

\[
Cb' = -0.101*R' - 0.338*G' + 0.439*B' + 128
\]

\[
Cr' = 0.439*R' - 0.399*G' - 0.040*B' + 128
\]

The destination image pDst has 4:2:0 sampling format (see Table “Planar Image Formats” for more details).

The values of roiSize.width and roiSize.height should be multiples of 2. Otherwise, the function reduces their original values to the nearest multiples of 2, performs operation, and returns a warning message.

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr

Indicates an error condition if pSrc or pDst is NULL.

ippStsSizeErr

Indicates an error condition if roiSize.width is less than 2 or roiSize.height is less than 2.

ippStsDoubleSize

Indicates a warning if roiSize has a field that is not a multiple of 2.

BGRToYCbCr420_709HDTV

Converts a BGR image to the YCbCr image with 4:2:0 sampling for ITU-R BT.709 HDTV signal.

Syntax

IppStatus ippiBGRToYCbCr420_709HDTV_8u_AC4P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

Include Files

ippcc.h
Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc  Pointer to the source image ROI.
srcStep  Distance in bytes between starts of consecutive lines in the source image.
pDSt  An array of pointers to ROI in separate planes of the destination image.
dstStep  An array of distances in bytes between starts of consecutive lines in the destination image planes.
roiSize  Size of the source and destination ROI in pixels.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts a four-channel gamma-corrected B'G'R' image pSrc to the planar Y'Cb'Cr' image pDSt for digital component video signals complied with the ITU-R BT.709 Recommendation [ITU709] for high-definition TV (HDTV). The source image pixel values are in the range [16..235]. The conversion is performed according to the following formulas [Jack01]:

\[
Y' = 0.213*R' + 0.715*G' + 0.072*B'
\]
\[
Cb' = -0.117*R' - 0.394*G' + 0.511*B' + 128
\]
\[
Cr' = 0.511*R' - 0.464*G' - 0.047*B' + 128
\]

The values of \(Y'\) of the destination image are in the range [16..235], the values of \(Cb', Cr'\) are in the range [16..240]. They should be saturated at the 1 and 254 levels.

The destination image pDSt has the 4:2:0 sampling format (see Table "Planar Image Formats" for more details).

The values of roiSize.width and roiSize.height should be multiples of 2. Otherwise, the function reduces their original values to the nearest multiples of 2, performs the operation, and returns a warning message.

Return Values

ippStsNoErr  Indicates no error. Any other value indicates an error or a warning.
ippStsNullFtrErr  Indicates an error condition if pSrc or pDSt is NULL.
ippStsSizeErr  Indicates an error condition if roiSize.width is less than 2 or roiSize.height is less than 2.
ippStsDoubleSize  Indicates a warning if roiSize has a field that is not a multiple of 2.

BGRToYCrCb420_709CSC
Converts a BGR image to the YCrCb image with 4:2:0 sampling for ITU-R BT.709 CSC signal.
Syntax

IppStatus ippiBGRToYCrCb420_709CSC_8u_AC4P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiBGRToYCrCb420_709CSC_8u_C3P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc

Pointer to the source image ROI.

srcStep

Distance in bytes between starts of consecutive lines in the source image.

pDst

An array of pointers to ROI in separate planes of the destination image.

dstStep

An array of distances in bytes between starts of consecutive lines in the destination image planes.

roiSize

Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts a three- or four-channel gamma-corrected B’G’R’ image pSrc to the planar Y’Cr’Cb’ image pDst for digital component video signals complied with the ITU-R BT.709 Recommendation [ITU709] for computer systems consideration (CSC). The source image pixel values are in the range [0..255]. The conversion is performed according to the following formulas [Jack01]:

\[
Y' = 0.183*R' + 0.614*G' + 0.062*B' + 16
\]
\[
Cb' = -0.101*R' - 0.338*G' + 0.439*B' + 128
\]
\[
Cr' = 0.439*R' - 0.399*G' - 0.040*B' + 128
\]

The destination image pDst has 4:2:0 sampling format (see Table “Planar Image Formats” for more details).

The values of roiSize.width and roiSize.height should be multiples of 2. Otherwise, the function reduces their original values to the nearest multiples of 2, performs the operation, and returns a warning message.

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr

Indicates an error condition if pSrc or pDst is NULL.

ippStsSizeErr

Indicates an error condition if roiSize.width is less than 2 or roiSize.height is less than 2.
Indicates a warning if `roiSize` has a field that is not a multiple of 2.

### YCbCr420ToBGR

*Converts a YCbCr image with the 4:2:0 sampling to the BGR image.*

**Syntax**

```c
IppStatus ippiYCbCr420ToBGR_8u_P3C3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiYCbCr420ToBGR_8u_P3C4R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);
```

**Include Files**

`ippcc.h`

**Domain Dependencies**

*Headers:* `ippcore.h`, `ippvm.h`, `ipps.h`, `ippi.h`

*Libraries:* `ippcore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`

**Parameters**

- `pSrc`: An array of pointers to ROI in separate planes of the source image.
- `srcStep`: An array of distances in bytes between starts of consecutive lines in the source image planes.
- `pDst`: Pointer to the destination image ROI.
- `dstStep`: Distance in bytes between starts of consecutive lines in the destination image.
- `roiSize`: Size of the source and destination ROI in pixels.
- `aval`: Constant value to create fourth channel.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the Y'Cb'Cr' image `pSrc` with the 4:2:0 sampling (see Table "Planar Image Formats" for more details) to the gamma-corrected three- or four-channel B'G'R' image `pDst`. The conversion is performed according to the same formulas as the function `ippiYCbCrToRGB` does.

Fourth channel is created by setting channel values to the constant value `aval`.

The values of `roiSize.width` and `roiSize.height` should be multiples of 2. If not the function reduces their original values to the nearest multiples of 2, performs operation, and returns warning message.

**Return Values**

- `ippStsNoErr`: Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr`: Indicates an error condition if `pSrc` or `pDst` is NULL.
Indicates an error condition if \textit{roiSize} has a field with a zero or negative value.
Indicates a warning if \textit{roiSize} has a field that is not a multiple of 2.

\textbf{YCbCr420ToBGR\_709CSC}

\textit{Converts a YCbCr image with 4:2:0 sampling to the BGR image for ITU-R BT.709 CSC signal.}

\textbf{Syntax}

\begin{verbatim}
IppStatus ippiYCbCr420ToBGR_709CSC_8u_P3C3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);
\end{verbatim}

\textbf{Include Files}

ippcc.h

\textbf{Domain Dependencies}

\textbf{Headers:} ippcore.h, ippvm.h, ipps.h,ippi.h  
\textbf{Libraries:} ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

\textbf{Parameters}

\begin{itemize}
\item \textit{pSrc}  
\quad An array of pointers to ROI in separate planes of the source image.
\item \textit{srcStep}  
\quad An array of distances in bytes between starts of consecutive lines in the source image planes.
\item \textit{pDst}  
\quad Pointer to the destination image ROI.
\item \textit{dstStep}  
\quad Distance in bytes between starts of consecutive lines in the destination image.
\item \textit{roiSize}  
\quad Size of the source and destination ROI in pixels.
\end{itemize}

\textbf{Description}

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts a planar Y'Cb'Cr' image \textit{pSrc} to the three-channel gamma-corrected B'G'R' image \textit{pDst} for digital component video signals complied with the ITU-R BT.709 Recommendation [ITU709] for computer systems consideration (CSC). The conversion is performed according to the following formulas [Jack01]:

\begin{align*}
R' &= 1.164\times(Y' - 16) + 1.793\times(Cr' - 128) \\
G' &= 1.164\times(Y' - 16) - 0.534\times(Cr' - 128) - 0.213\times(Cb' - 128) \\
B' &= 1.164\times(Y' - 16) + 2.115\times(Cb' - 128)
\end{align*}

The output \textit{R'G'B'} values are saturated to the range [0..255]. The source image \textit{pDst} has the 4:2:0 sampling format (see Table "Planar Image Formats" for more details).

The values of \textit{roiSize.width} and \textit{roiSize.height} should be multiples of 2. Otherwise, the function reduces their original values to the nearest multiples of 2, performs the operation, and returns a warning message.
Return Values

ippStsNoErr  Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  Indicates an error condition if pSrc or pDst is NULL.

ippStsSizeErr  Indicates an error condition if roiSize has a field with a zero or negative value.

ippStsDoubleSize  Indicates a warning if roiSize has a field that is not a multiple of 2.

YCbCr420ToBGR_709HDTV

Converts a YCbCr image with 4:2:0 sampling to the BGR image for ITU-R BT.709 HDTV signal.

Syntax

IppStatus ippiYCbCr420ToBGR_709HDTV_8u_P3C4R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc  An array of pointers to ROI in separate planes of the source image.

srcStep  An array of distances in bytes between starts of consecutive lines in the source image planes.

pDst  Pointer to the destination image ROI.

dstStep  Distance in bytes between starts of consecutive lines in the destination image.

roiSize  Size of the source and destination ROI in pixels.

aval  Constant value to create fourth channel.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts a planar $Y'Cb'Cr'$ image $pSrc$ to the four-channel gamma-corrected $B'G'R'$ image $pDst$ for digital component video signals complied with the ITU-R BT.709 Recommendation [ITU709] for high-definition TV (HDTV). The values of $Y'$ are in the range [16..235], the values of $Cb'$, $Cr'$ are in the range [16..240]. The conversion is performed according to the following formulas [Jack01]:

\[
\begin{align*}
R' &= Y' + 1.540*(Cr' - 128) \\
G' &= Y' - 0.459*(Cr' - 128) - 0.183*(Cb' - 128) \\
B' &= Y' + 1.816*(Cb' - 128)
\end{align*}
\]

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The destination image pixel values have a nominal range [16..235]. The resulting R'G'B' values should be saturated at the 0 and 255 levels.

The source image \( pDst \) has the 4:2:0 sampling format (see Table "Planar Image Formats" for more details).

The values of \( roiSize.width \) and \( roiSize.height \) should be multiples of 2. Otherwise, the function reduces their original values to the nearest multiples of 2, performs an operation, and returns a warning message.

**Return Values**

- \( ippStsNoErr \): Indicates no error. Any other value indicates an error or a warning.
- \( ippStsNullPtrErr \): Indicates an error condition if \( pSrc \) or \( pDst \) is NULL.
- \( ippStsSizeErr \): Indicates an error condition if \( roiSize \) has a field with a zero or negative value.
- \( ippStsDoubleSize \): Indicates a warning if \( roiSize \) has a field that is not a multiple of 2.

**BGRToYCrCb420**

*Converts a BGR image to the YCrCb image with 4:2:0 sampling format.*

**Syntax**

```c
IppStatus ippiBGRToYCrCb420_8u_C3P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiBGRToYCrCb420_8u_AC4P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
```

**Include Files**

ippcc.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- \( pSrc \): Pointer to the source image ROI.
- \( srcStep \): Distance in bytes between starts of consecutive lines in the source image.
- \( pDst \): An array of pointers to ROI in separate planes of the destination image.
- \( dstStep \): An array of distances in bytes between starts of consecutive lines in the destination image planes.
- \( roiSize \): Size of the source and destination ROI in pixels.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts a three- or four-channel gamma-corrected B'G'R' image \( pSrc \) to the planar Y'Cr'Cb' image \( pDst \) according to the same formulas as the function \( \text{ippiRGBToYCbCr} \) does. The destination image \( pDst \) has the 4:2:0 sampling format and the following order of pointers: Y-plane, Cr-plane, Cb-plane (see Table "Planar Image Formats" for more details).

### Return Values

- **ippiStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.
- **ippiStsNullPtrErr**
  Indicates an error condition if \( pSrc \) or \( pDst \) is NULL.
- **ippiStsSizeErr**
  Indicates an error condition if \( roiSize\.width \) is less than 2 or \( roiSize\.height \) is less than 2.

### BGRToYCbCr411

Converts a BGR image to the YCbCr planar image that has a 4:1:1 sampling format.

#### Syntax

```c
IppStatus ippiBGRToYCbCr411_8u_C3P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiBGRToYCbCr411_8u_AC4P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
```

#### Include Files

ippcc.h

#### Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

#### Parameters

- **pSrc**
  Pointer to the source image ROI.
- **srcStep**
  Distance in bytes between starts of consecutive lines in the source image.
- **pDst**
  An array of pointers to ROI in separate planes of the destination image.
- **dstStep**
  An array of distances in bytes between starts of consecutive lines in the destination image planes.
- **roiSize**
  Size of the source and destination ROI in pixels.

#### Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts a three- or four-channel gamma-corrected B'G'R' image \( pSrc \) to the planar Y'Cb'Cr' image \( pDst \) according to the same formulas as the function \( \text{ippiRGBToYCbCr} \) does. The difference is that \( \text{ippiBGRToYCbCr411} \) uses the 4:1:1 sampling format (see Table "Planar Image Formats" for more details).
Return Values

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error or a warning.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error condition if pSrc or pDst is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error condition if roiSize.width is less than 4 or roiSize.height is less than 1.</td>
</tr>
</tbody>
</table>

**YCbCr411ToBGR**

*Converts a YCbCr image that has 4:1:1 sampling format to the RGB color model.*

**Syntax**

```c
IppStatus ippiYCbCr411ToBGR_8u_P3C3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiYCbCr411ToBGR_8u_P3C4R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u aval);
```

**Include Files**

ippcc.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- `pSrc` An array of pointers to ROI in separate planes of the source image.
- `srcStep` An array of distances in bytes between starts of consecutive lines in the source image planes.
- `pDst` Pointer to the destination image ROI.
- `dstStep` Distance in bytes between starts of consecutive lines in the destination image.
- `roiSize` Size of the source and destination ROI in pixels.
- `aval` Constant value to create fourth channel.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the planar Y'Cb'Cr' image `pSrc` to the three- or four-channel image `pDst`. To compute gamma-corrected R'G'B' (B'G'R') channel values the above formulas are used. The difference is that ippiYCbCr411ToBGR uses the input data in the 4:1:1 sampling format (see Table "Planar Image Formats" for more details). Fourth channel is created by setting channel values to the constant value `aval`.

**Return Values**

- `ippStsNoErr` Indicates no error. Any other value indicates an error or a warning.
**RGBToXYZ**

Converts an RGB image to the XYZ color model.

**Syntax**

```c
IppStatus ippiRGBToXYZ_\<mod>(const Ipp\<datatype>\* pSrc, int srcStep, Ipp\<datatype>\* pDst, int dstStep, IppSize roiSize);
```

Supported values for `\<mod>`:

- `8u_C3R`
- `16u_C3R`
- `16s_C3R`
- `32f_C3R`
- `8u_AC4R`
- `16u_AC4R`
- `16s_AC4R`
- `32f_AC4R`

**Include Files**

`ippcc.h`

**Domain Dependencies**

Headers: `ippcore.h`, `ippvm.h`, `ipps.h`, `ippi.h`

Libraries: `ippcore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`

**Parameters**

- `pSrc`:
  Pointer to the source image ROI.

- `srcStep`:
  Distance in bytes between starts of consecutive lines in the source image.

- `pDst`:
  Pointer to the destination image ROI.

- `dstStep`:
  Distance in bytes between starts of consecutive lines in the destination image.

- `roiSize`:
  Size of the source and destination ROI in pixels.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the RGB image `pSrc` to the CIEXYZ image `pDst` according to the following basic equations:

\[
\begin{align*}
X &= 0.412453 \times R + 0.35758 \times G + 0.180423 \times B \\
Y &= 0.212671 \times R + 0.71516 \times G + 0.072169 \times B \\
Z &= 0.019334 \times R + 0.119193 \times G + 0.950227 \times B
\end{align*}
\]

The equations above are given on the assumption that R, G, and B values are normalized to the range \([0..1]\). In case of the floating-point data type, the input RGB values must already be in the range \([0..1]\). For integer data types, normalization is done by the conversion function internally.

The computed XYZ values are saturated if they fall out of range \([0..1]\).

In case of integer function flavors, these values are then scaled to the full range of the destination data type (see Table “Image Data Types and Ranges” in Chapter 2).
Return Values

ippStsNoErr  Indicates no error. Any other value indicates an error.
ippStsNullPtrErr  Indicates an error condition if pSrc or pDst is NULL.
ippStsSizeErr  Indicates an error condition if roiSize has a field with a zero or negative value.

XYZToRGB

Converts an XYZ image to the RGB color model.

Syntax

IppStatus ippiXYZToRGB_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

<table>
<thead>
<tr>
<th>8u_C3R</th>
<th>16u_C3R</th>
<th>16s_C3R</th>
<th>32f_C3R</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_AC4R</td>
<td>16u_AC4R</td>
<td>16s_AC4R</td>
<td>32f_AC4R</td>
</tr>
</tbody>
</table>

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc  Pointer to the source image ROI.
srcStep  Distance in bytes between starts of consecutive lines in the source image.
pDst  Pointer to the destination image ROI.
dstStep  Distance in bytes between starts of consecutive lines in the destination image.
roiSize  Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the CIEXYZ image pSrc to the RGB image pDst according to the following basic equations:

\[
\begin{align*}
R &= 3.240479 \times X - 1.53715 \times Y - 0.498535 \times Z \\
G &= -0.969256 \times X + 1.875991 \times Y + 0.041556 \times Z \\
B &= 0.055648 \times X - 0.204043 \times Y + 1.057311 \times Z
\end{align*}
\]

The equations above are given on the assumption that \(X, Y,\) and \(Z\) values are in the range \([0..1]\). In case of the floating-point data type, the input XYZ values must already be in the range \([0..1]\). For integer data types, normalization is done by the conversion function internally.
The computed RGB values are saturated if they fall out of range [0..1].
In case of integer function flavors, these values are then scaled to the full range of the destination data type (see Table "Image Data Types and Ranges" in Chapter 2).

Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error condition if pSrc or pDst is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error condition if roiSize has a field with a zero or negative value.</td>
</tr>
</tbody>
</table>

**RGBToLUV, BGRToLUV**

*Converts an RGB or BGR image to the LUV color model.*

**Syntax**

**Case 1: RGB to LUV**

```
IppStatus ippiRGBToLUV_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>*
pDst, int dstStep, IppiSize roiSize);
```

Supported values for mod:

- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 8u_AC4R
- 16u_AC4R
- 16s_AC4R
- 32f_AC4R

**Case 2: BGR to LUV**

```
IppStatus ippiBGRToLUV_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>*
pDst, int dstStep, IppiSize roiSize);
```

Supported values for mod:

- 8u_C3R
- 32f_C3R

**Include Files**

ippcc.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the RGB or BGR image pSrc to the CIE LUV image pDst in two steps. First, the conversion is done into CIE XYZ format, using equations defined for the `ippiRGBToXYZ` function. After that, conversion to LUV image is performed in accordance with the following equations:

\[
\begin{align*}
L &= 116. \cdot \left(\frac{Y}{Y_n}\right)^{1/3} - 16. \\
U &= 13. \cdot L \cdot (u - u_n) \\
V &= 13. \cdot L \cdot (v - v_n)
\end{align*}
\]

where

\[
\begin{align*}
u &= 4.*X / (X + 15.*Y + 3.*Z) \\
v &= 9.*Y / (X + 15.*Y + 3.*Z)
\end{align*}
\]

\[
u_n = 0.197839 \quad v_n = 0.468342
\]

The computed values of the L component are in the range [0..100], U component in the range [-134..220], and V component in the range [-140..122].

The equations above are given on the assumption that R, G, and B values are normalized to the range [0..1]. In case of the floating-point data type, the input RGB values must already be in the range [0..1]. For integer data types, normalization is done by the conversion function internally.

In case of 8u data type, the computed L, U, and V values are quantized and converted to fit in the range [0..IPP_MAX_8U] as follows:

\[
\begin{align*}
L &= L \cdot \text{IPP_MAX_8U} / 100. \\
U &= (U + 134.) \cdot \text{IPP_MAX_8U} / 354. \\
V &= (V + 140.) \cdot \text{IPP_MAX_8U} / 262.
\end{align*}
\]

In case of 16u data type, the computed L, U, and V values are quantized and converted to fit in the range [0..IPP_MAX_16U] as follows:

\[
\begin{align*}
L &= L \cdot \text{IPP_MAX_16U} / 100. \\
U &= (U + 134.) \cdot \text{IPP_MAX_16U} / 354. \\
V &= (V + 140.) \cdot \text{IPP_MAX_16U} / 262.
\end{align*}
\]

In case of 16s data type, the computed L, U, and V values are quantized and converted to fit in the range [IPP_MIN_16S..IPP_MAX_16S] as follows:

\[
\begin{align*}
L &= L \cdot \text{IPP_MAX_16U} / 100. + \text{IPP_MIN_16S} \\
U &= (U + 134.) \cdot \text{IPP_MAX_16U} / 354. + \text{IPP_MIN_16S} \\
V &= (V + 140.) \cdot \text{IPP_MAX_16U} / 262. + \text{IPP_MIN_16S}
\end{align*}
\]

For 32f data type, no further conversion is done and L, U, and V components remain in the ranges [0..100], [-134..220], and [-140..122], respectively.

**Return Values**

**ippiStsNoErr**

Indicates no error. Any other value indicates an error.
ippStsNullPtrErr  Indicates an error condition if \(pSrc\) or \(pDst\) is NULL.

ippStsSizeErr  Indicates an error condition if \(roiSize\) has a field with a zero or negative value.

**LUVToRGB, LUVToBGR**

*Converts a LUV image to the RGB or BGR color model.*

**Syntax**

**Case 1: LUV to RGB**

IppStatus ippiLUVToRGB_<mod>(const Ipp<datatype>* \(pSrc\), int \(srcStep\), Ipp<datatype>* \(pDst\), int \(dstStep\), IppiSize \(roiSize\));

Supported values for \(mod\):

\[
\begin{array}{cccc}
8u\_C3R & 16u\_C3R & 16s\_C3R & 32f\_C3R \\
8u\_AC4R & 16u\_AC4R & 16s\_AC4R & 32f\_AC4R \\
\end{array}
\]

**Case 2: LUV to BGR**

IppStatus ippiLUVToBGR_<mod>(const Ipp<datatype>* \(pSrc\), int \(srcStep\), Ipp<datatype>* \(pDst\), int \(dstStep\), IppiSize \(roiSize\));

Supported values for \(mod\):

\[
\begin{array}{cccc}
8u\_C3R & 32f\_C3R \\
\end{array}
\]

**Include Files**

ippcc.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

**Parameters**

\(pSrc\)  Pointer to the source image ROI.

\(srcStep\)  Distance in bytes between starts of consecutive lines in the source image.

\(pDst\)  Pointer to the destination image ROI.

\(dstStep\)  Distance in bytes between starts of consecutive lines in the destination image.

\(roiSize\)  Size of the source and destination ROI in pixels.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the CIE LUV image \(pSrc\) to the RGB or BGR image \(pDst\) in two steps. First, the conversion is carried out into CIE XYZ format.
To accomplish it, LUV components are transformed back into their original range. This is done for different data types in the following way.

**For 8u data type:**

\[
\begin{align*}
L &= L \times \frac{100.}{IPP\_MAX\_8U} \\
U &= (U \times \frac{354.}{IPP\_MAX\_8U}) - 134. \\
V &= (V \times \frac{262.}{IPP\_MAX\_8U}) - 140.
\end{align*}
\]

**For 16u data type:**

\[
\begin{align*}
L &= L \times \frac{100.}{IPP\_MAX\_16U} \\
U &= (U \times \frac{354.}{IPP\_MAX\_16U}) - 134. \\
V &= (V \times \frac{262.}{IPP\_MAX\_16U}) - 140.
\end{align*}
\]

**For 16s data type:**

\[
\begin{align*}
L &= (L - IPP\_MIN\_16S) \times \frac{100.}{IPP\_MAX\_16U} \\
U &= ((U - IPP\_MIN\_16S) \times \frac{354.}{IPP\_MAX\_16U}) - 134. \\
V &= ((V - IPP\_MIN\_16S) \times \frac{262.}{IPP\_MAX\_16U}) - 140.
\end{align*}
\]

After that, conversion to XYZ format takes place as follows:

\[
\begin{align*}
Y &= Y_n * \left( \frac{(L + 16.)}{116.} \right)^3. \\
X &= -9.* Y * u / ((u - 4.)* v - u* v) \\
Z &= (9.* Y - 15*v*Y - v*X) / 3.* v \\
\end{align*}
\]

where

\[
\begin{align*}
u &= U / (13.* L) + u_n \\
v &= V / (13.* L) + v_n \\
\end{align*}
\]

and

\[
\begin{align*}
u_n &= 4.*x_n / (-2.*x_n + 12.*y_n + 3.) \\
v_n &= 9.*y_n / (-2.*x_n + 12.*y_n + 3.) \\
\end{align*}
\]

Here \(x_n = 0.312713\), \(y_n = 0.329016\) are the CIE chromaticity coordinates of the D65 white point, and \(Y_n = 1.0\) is the luminance of the D65 white point.

After this intermediate conversion is done, the obtained XYZ image is then converted to the destination RGB or BGR format using equations defined for the ippiXYZToRGB function.

**Return Values**

- **ippiStsNoErr**: Indicates no error. Any other value indicates an error.
- **ippiStsNullPtrErr**: Indicates an error condition if pSrc or pDst is NULL.
- **ippiStsSizeErr**: Indicates an error condition if roiSize has a field with a zero or negative value.

**BGRToLab, RGBToLab**

*Converts a BGR or RGB image to the Lab color model.*
**Syntax**

**Case 1: BGR to Lab**

IppStatus ippiBGRToLab_8u_C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);

IppStatus ippiBGRToLab_8u16u_C3R(const Ipp8u* pSrc, int srcStep, Ipp16u* pDst, int dstStep, IppiSize roiSize);

IppStatus ippiBGRToLab_32f_C3R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize);

**Case 2: RGB to Lab**

IppStatus ippiRGBToLab_8u_C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);

IppStatus ippiRGBToLab_32f_C3R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize);

IppStatus ippiRGBToLab_32f_P3R(const Ipp32f* pSrc[3], int srcStep[3], Ipp32f* pDst[3], int dstStep[3], IppiSize roiSize);

IppStatus ippiRGBToLab_64f_P3R(const Ipp64f* pSrc[3], int srcStep[3], Ipp64f* pDst[3], int dstStep[3], IppiSize roiSize);

**Case 3: RGB to Lab with platform-aware functions**

IppStatus ippiRGBToLab_32f_P3R_L(const Ipp32f* pSrc[3], IppSizeL srcStep[3], Ipp32f* pDst[3], IppSizeL dstStep[3], IppiSizeL roiSize);

IppStatus ippiRGBToLab_64f_P3R_L(const Ipp64f* pSrc[3], IppSizeL srcStep[3], Ipp64f* pDst[3], IppSizeL dstStep[3], IppiSizeL roiSize);

**Case 4: RGB to Lab with TL functions based on the Platform Aware API**

IppStatus ippiRGBToLab_32f_P3R_LT(const Ipp32f* pSrc[3], IppSizeL srcStep[3], Ipp32f* pDst[3], IppSizeL dstStep[3], IppiSizeL roiSize);

IppStatus ippiRGBToLab_64f_P3R_LT(const Ipp64f* pSrc[3], IppSizeL srcStep[3], Ipp64f* pDst[3], IppSizeL dstStep[3], IppiSizeL roiSize);

**Case 5: RGB to Lab with TL functions based on the Classic API**

IppStatus ippiRGBToLab_32f_P3R_T(const Ipp32f* pSrc[3], int srcStep[3], Ipp32f* pDst[3], int dstStep[3], IppiSize roiSize);

IppStatus ippiRGBToLab_64f_P3R_T(const Ipp64f* pSrc[3], int srcStep[3], Ipp64f* pDst[3], int dstStep[3], IppiSize roiSize);

**Include Files**

ippcc.h

ippcc_l.h

ippcc_tl.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Parameters

\( pSrc, pSrc[3] \)  
Pointer to the source image ROI.

\( srcStep, srcStep[3] \)  
Distance in bytes between starts of consecutive lines in the source image.

\( pDst, pDst[3] \)  
Pointer to the destination image ROI.

\( dstStep, dstStep[3] \)  
Distance in bytes between starts of consecutive lines in the destination image.

\( roiSize \)  
Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the BGR or RGB image \( pSrc \) to the CIE Lab image \( pDst \), and vice versa. Conversion to Lab consists of two steps. First, the conversion is done into CIE XYZ format, using equations defined for the function \( \text{ippiRGBToXYZ} \). After that, conversion to the Lab image is performed in accordance with the following equations:

\[
    L = 116. \cdot (Y/Y_n)^{1/3} - 16 \quad \text{for } Y/Y_n > 0.008856 \\
    L = 903.3 \cdot (Y/Y_n)^{1/3} \quad \text{for } Y/Y_n \leq 0.008856 \\
    a = 500. \cdot [f(X/X_n) - f(Y/Y_n)] \\
    b = 200. \cdot [f(Y/Y_n) - f(Z/Z_n)]
\]

where

\[
f(t) = \begin{cases} t^{1/3}, & t > (6/29)^3 \\ \left( \frac{1}{3} \left( \frac{6}{29} \right)^2 \right) t + \frac{4}{29} & t \leq (6/29)^3 \end{cases}
\]

Here \( Y_n = 1.0, X_n = 0.950455, Z_n = 1.088753 \) for the D65 white point with the CIE chromaticity coordinates \( x_n = 0.312713, y_n = 0.329016 \).

The equations above are given on the assumption that initial B, G, R values are normalized to the range \([0..1]\). The computed values of the \( L \) component are in the range \([0..100]\), \( a \) and \( b \) component values are in the range \([-128..127]\).

These values are quantized and scaled to the 8-bit range of 0 to 255 for 8u_C3 flavors:

\[
    L = L \cdot 255./100. \\
    a = (a + 128.) \\
    b = (a + 128.)
\]

or to the 16-bit range of 0 to 65535 for ippiBGRToLab_8u16u_C3R:

\[
    L = L \cdot 65535./100. \\
    a = (a + 128.)* 255 \\
    b = (a + 128.)* 255
\]
Return Values

ippStsNoErr Indicates no error. Any other value indicates an error.

ippStsNullPtrErr Indicates an error condition if pSrc, pSrc[3], pDst, or pDst[3] is NULL.

ippStsSizeErr Indicates an error condition if roiSize has a field with a zero or negative value.

LabToBGR, LabToRGB

Converts a Lab image to the BGR or RGB color model.

Syntax

Case 1: Lab to BGR

IppStatusippiLabToBGR_8u_C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatusippiLabToBGR_16u8u_C3R(const Ipp16u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatusippiLabToBGR_32f_C3R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize);

Case 2: Lab to RGB

IppStatusippiLabToRGB_8u_C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatusippiLabToRGB_32f_C3R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize);
IppStatusippiLabToRGB_32f_P3R(const Ipp32f* pSrc[3], int srcStep[3], Ipp32f* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatusippiLabToRGB_64f_P3R(const Ipp64f* pSrc[3], int srcStep[3], Ipp64f* pDst[3], int dstStep[3], IppiSize roiSize);

Case 3: Lab to RGB with platform-aware functions

IppStatusippiLabToRGB_32f_P3R_L(const Ipp32f* pSrc[3], IppSizeL srcStep[3], Ipp32f* pDst[3], IppSizeL dstStep[3], IppiSizeL roiSize);
IppStatusippiLabToRGB_64f_P3R_L(const Ipp64f* pSrc[3], IppSizeL srcStep[3], Ipp64f* pDst[3], IppSizeL dstStep[3], IppiSizeL roiSize);

Case 4: Lab to RGB with TL functions based on the Platform Aware API

IppStatusippiLabToRGB_32f_P3R_LT(const Ipp32f* pSrc[3], IppSizeL srcStep[3], Ipp32f* pDst[3], IppSizeL dstStep[3], IppiSizeL roiSize);
IppStatusippiLabToRGB_64f_P3R_LT(const Ipp64f* pSrc[3], IppSizeL srcStep[3], Ipp64f* pDst[3], IppSizeL dstStep[3], IppiSizeL roiSize);

Case 5: Lab to RGB with TL functions based on the Classic API

IppStatusippiLabToRGB_32f_P3R_T(const Ipp32f* pSrc[3], int srcStep[3], Ipp32f* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatusippiLabToRGB_64f_P3R_T(const Ipp64f* pSrc[3], int srcStep[3], Ipp64f* pDst[3], int dstStep[3], IppiSize roiSize);
Include Files
ippcc.h
ippcc_l.h
ippcc_tl.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

$pSrc, pSrc[3]$  
Pointer to the source image ROI.

$srcStep, srcStep[3]$  
Distance in bytes between starts of consecutive lines in the source image.

$pDst, pDst[3]$  
Pointer to the destination image ROI.

$dstStep, dstStep[3]$  
Distance in bytes between starts of consecutive lines in the destination image.

$roiSize$  
Size of the source and destination ROI in pixels.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the CIE Lab image $pSrc$ to the BGR or RGB image $pDst$ in two steps. First, the conversion is carried out into CIE XYZ format.

To accomplish it, Lab components are transformed back into their original range. This is done for different data types in the following way.

For $8u$ data type:

$L = L \times 100./255.$

$a = a - 128.$

$b = b - 128.$

For $16u$ data type:

$L = L \times 100./65535.$

$a = (a/255. - 128.)$

$b = (b/255.) - 128.)$

After that, conversion to XYZ format takes place as follows:

$Y = Y_n \times P^3.$

$X = X_n \times (P + a/500.)^3.$

$Z = Z_n \times (P - b/200.)^3.$

where

$P = (L +16)/116.$

After this intermediate conversion is done, the obtained XYZ image is then converted to the destination BGR or RGB format using equations defined for the ippiXYZToRGB function.
Return Values

- ippStsNoErr: Indicates no error. Any other value indicates an error.
- ippStsNullPtrErr: Indicates an error condition if \( pSrc, pSrc[3], pDst, \) or \( pDst[3] \) is NULL.
- ippStsSizeErr: Indicates an error condition if \( roiSize \) has a field with a zero or negative value.

**RGBToYCC**

*Converts an RGB image to the YCC color model.*

**Syntax**

\[
\text{IppStatus ippiRGBToYCC}_<\text{mod}>(\text{const Ipp}\langle\text{datatype}\rangle^* pSrc, \text{int srcStep}, \text{Ipp}\langle\text{datatype}\rangle^* pDst, \text{int dstStep}, \text{IppiSize roiSize});
\]

**Supported values for mod:**

- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 8u_AC4R
- 16u_AC4R
- 16s_AC4R
- 32f_AC4R

**Include Files**

ippcc.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- \( pSrc \): Pointer to the source image ROI.
- \( srcStep \): Distance in bytes between starts of consecutive lines in the source image.
- \( pDst \): Pointer to the destination image ROI.
- \( dstStep \): Distance in bytes between starts of consecutive lines in the destination image.
- \( roiSize \): Size of the source and destination ROI in pixels.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the gamma-corrected \( R'B'G' \) image \( pSrc \) to the \( \text{PhotoY'C'C'} \) image \( pDst \) according to the following basic equations:

- \( Y' = 0.299*R' + 0.587*G' + 0.114*B' \)
- \( C1' = -0.299*R' - 0.587*G' + 0.886*B' = B' - Y \)
- \( C2' = 0.701*R' - 0.587*G' - 0.114*B' = R' - Y \)

The equations above are given on the assumption that \( R', G', \) and \( B' \) values are normalized to the range \([0..1]\). In case of the floating-point data type, the input \( R'G'B' \) values must already be in the range \([0..1]\). For integer data types, normalization is done by the conversion function internally.
The computed $Y', C1', C2'$ values are then quantized and converted to fit in the range $[0..1]$ as follows:

$Y' = 1. / 1.402 \times Y'$

$C1' = 111.4 / 255. \times C1' + 156. / 255.$

$C2' = 135.64 / 255. \times C2' + 137. / 255.$

In case of integer function flavors, these values are then scaled to the full range of the destination data type (see Table "Image Data Types and Ranges" in Chapter 2).

**Return Values**

- **ippStsNoErr**
  - Indicates no error. Any other value indicates an error.

- **ippStsNullPtrErr**
  - Indicates an error condition if $pSrc$ or $pDst$ is NULL.

- **ippStsSizeErr**
  - Indicates an error condition if $roiSize$ has a field with a zero or negative value.

**YCCToRGB**

*Converts a YCC image to the RGB color model.*

**Syntax**

```c
IppStatus ippiYCCToRGB_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);
```

**Supported values for mod:**

- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 8u_AC4R
- 16u_AC4R
- 16s_AC4R
- 32f_AC4R

**Include Files**

ippcc.h

**Domain Dependencies**

*Headers:* ippcore.h, ippvm.h, ipps.h, ippi.h

*Libraries:* ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

**Parameters**

- **pSrc**
  - Pointer to the source image ROI.
- **srcStep**
  - Distance in bytes between starts of consecutive lines in the source image.
- **pDst**
  - Pointer to the destination image ROI.
- **dstStep**
  - Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**
  - Size of the source and destination ROI in pixels.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the PhotoY'C'C' image $pSrc$ to the R'B'G' image $pDst$. The function ippiYCCToRGB first restores normal luminance and chrominance data as:
\[ Y' = 1.3584 \times Y' \]
\[ C1' = 2.2179 \times (C1' - 156./255.) \]
\[ C2' = 1.8215 \times (C2' - 137./255.) \]

The equations above are given on the assumption that source \( Y \), \( C1 \), and \( C2 \) values are normalized to the range \([0..1]\). In case of the floating-point data type, the input YCC values must already be in the range \([0..1]\). For integer data types, normalization is done by the conversion function internally.

After that, YCC data are transformed into RGB format according to the following basic equations:

\[ R' = Y' + C2' \]
\[ G' = Y' - 0.194 \times C1' - 0.509 \times C2' \]
\[ B' = Y' + C1' \]

In case of integer function flavors, the computed \( R' \times B' \times G' \) values are then scaled to the full range of the destination data type (see Table "Image Data Types and Ranges" in Chapter 2).

**Return Values**

- **ippStsNoErr** Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr** Indicates an error condition if \( pSrc \) or \( pDst \) is NULL.
- **ippStsSizeErr** Indicates an error condition if \( roiSize \) has a field with a zero or negative value.

**RGBToHLS**

*Converts an RGB image to the HLS color model.*

**Syntax**

\[
\text{IppStatus} \ \text{ippiRGBToHLS}_<\text{mod}>(\text{const Ipp<datatype> *} \ pSrc, \ \text{int} \ \text{srcStep}, \ \text{Ipp<datatype> *} \ pDst, \ \text{int} \ \text{dstStep}, \ \text{IppiSize} \ \text{roiSize});
\]

Supported values for \( \text{mod} \):

- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 8u_AC4R
- 16u_AC4R
- 16s_AC4R
- 32f_AC4R

**Include Files**

ippcc.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc** Pointer to the source image ROI.
- **srcStep** Distance in bytes between starts of consecutive lines in the source image.
- **pDst** Pointer to the destination image ROI.
**dstStep**

Distance in bytes between starts of consecutive lines in the destination image.

**roiSize**

Size of the source and destination ROI in pixels.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the R'B'G' image `pSrc` to the HLS image `pDst`. For function flavors operating on the floating point data, source RGB values must be in the range [0..1].

The conversion algorithm from RGB to HLS can be represented in pseudocode as follows:

```plaintext
// Lightness:
M1 = max(R,G,B); M2 = min(R,G,B); L = (M1+M2)/2
// Saturation:
if M1 = M2 then // achromatics case
    S = 0
    H = 0
else // chromatics case
    if L <= 0.5 then
        S = (M1-M2) / (M1+M2)
    else
        S = (M1-M2) / (2-M1-M2)
// Hue:
Cr = (M1-R) / (M1-M2)
Cg = (M1-G) / (M1-M2)
Cb = (M1-B) / (M1-M2)
if R = M1 then H = Cb - Cg              // change R=M2 to R=M1
if G = M1 then H = 2 + Cr - Cb         // change G=M2 to G=M1
if B = M1 then H = 4 + Cg - Cr         // change B=M2 to B=M1
H = 60*H
if H < 0 then H = H + 360
```

For floating point function flavors, the computed `H`, `L`, `S` values are scaled to the range [0..1]. In case of integer function flavors, these values are scaled to the full range of the destination data type (Table "Image Data Types and Ranges").

**Return Values**

- `ippStsNoErr` Indicates no error. Any other value indicates an error.
- `ippStsNullPtrErr` Indicates an error condition if `pSrc` or `pDst` is NULL.
- `ippStsSizeErr` Indicates an error condition if `roiSize` has a field with a zero or negative value.

**HLSToRGB**

**Converts an HLS image to the RGB color model.**

**Syntax**

```c
IppStatus ippiHLSToRGB_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);
```

**Supported values for mod:**

- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters

pSrc

Pointer to the source image ROI.

srcStep

Distance in bytes between starts of consecutive lines in the source image.

pDst

Pointer to the destination image ROI.

dstStep

Distance in bytes between starts of consecutive lines in the destination image.

roiSize

Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the HLS image pSrc to the R'B'G' image pDst. For function flavors operating on the floating point data, source HLS values must be in the range [0..1]. The conversion algorithm from HLS to RGB can be represented in pseudocode as follows:

```plaintext
if L <= 0.5 then
    M2 = L * (1 + S)
else if h < 60 then
    R = (M1 + (M2 - M1) * h / 60)
else if h < 180 then
    R = M2
else if h < 240 then
    R = M1 + (M2 - M1) * (240 - h) / 60
else if h < 360 then
    R = h - 360
else
    h = h - 360

M1 = 2 * L - M2

if S = 0 then
    G = M1 + (M2 - M1) * h / 60
else if h < 60 then
    G = M2
else if h < 180 then
    G = M1 + (M2 - M1) * (240 - h) / 60
else
    G = M1

h = H

if h < 60 then
    B = (M1 + (M2 - M1) * h / 60)
else if h < 180 then
    B = M2
else if h < 240 then
    B = M1 + (M2 - M1) * (240 - h) / 60
else
    B = M1
```

For floating point function flavors, the computed R',G',B' values are scaled to the range [0..1]. In case of integer function flavors, these values are scaled to the full range of the destination data type (see Table "Image Data Types and Ranges" in Chapter 2).

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error.

ippStsNullPtrErr

Indicates an error condition if pSrc or pDst is NULL.

ippStsSizeErr

Indicates an error condition if roiSize has a field with a zero or negative value.

BGRToHLS

Converts a BGR image to the HLS color model.
Syntax

IppStatus ippiBGRToHLS_8u_AC4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiBGRToHLS_8u_C3P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep, IppiSize roiSize);
IppStatus ippiBGRToHLS_8u_AC4P4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[4], int dstStep, IppiSize roiSize);
IppStatus ippiBGRToHLS_8u_P3C3R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiBGRToHLS_8u_AP4C4R(const Ipp8u* pSrc[4], int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiBGRToHLS_8u_P3R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst[3], int dstStep, IppiSize roiSize);
IppStatus ippiBGRToHLS_8u_AP4R(const Ipp8u* pSrc[4], int srcStep, Ipp8u* pDst[4], int dstStep, IppiSize roiSize);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters

pSrc          Pointer to the ROI in the pixel-order source image. An array of pointers to ROI in each plane in the planar source image.
srcStep       Distance in bytes between starts of consecutive lines in the source image.
pDst          Pointer to the ROI in the pixel-order destination image. An array of pointers to ROI in each plane in the planar destination image.
dstStep       Distance in bytes between starts of consecutive lines in the destination image.
roiSize       Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the B’G’R’ image pSrc to the HLS image pDst according to the same formula as the function ippiRGBToHLS does.

Return Values

ippStsNoErr     Indicates no error. Any other value indicates an error.
ippStsNullPtrErr Indicates an error condition if pSrc or pDst is NULL.
ippStsSizeErr   Indicates an error condition if roiSize has a field with a zero or negative value.
HLSToBGR
Converts an HLS image to the RGB color model.

Syntax
IppStatusippiHLSToBGR_8u_C3P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep, IppiSize roiSize);
IppStatusippiHLSToBGR_8u_AC4P4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[4], int dstStep, IppiSize roiSize);
IppStatusippiHLSToBGR_8u_AP4R(const Ipp8u* pSrc[4], int srcStep, Ipp8u* pDst[4], int dstStep, IppiSize roiSize);
IppStatusippiHLSToBGR_8u_AP4C4R(const Ipp8u* pSrc[4], int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatusippiHLSToBGR_8u_P3C3R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters
pSrc
Pointer to the ROI in the pixel-order source image. An array of pointers to ROI in each plane in the planar source image.
srcStep
Distance in bytes between starts of consecutive lines in the source image.
pDst
Pointer to the ROI in the pixel-order destination image. An array of pointers to ROI in each plane in the planar destination image.
dstStep
Distance in bytes between starts of consecutive lines in the destination image.
roiSize
Size of the source and destination ROI in pixels.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the HLS image pSrc to the B'G'R' image pDst according to the same formula as the functionippiHLSToRGB does.

Return Values
ippStsNoErr
Indicates no error. Any other value indicates an error.
ippStsNullPtrErr
Indicates an error condition if pSrc or pDst is NULL.
Indicates an error condition if `roiSize` has a field with a zero or negative value.

**RGBToHSV**

*Converts an RGB image to the HSV color model.*

**Syntax**

```c
IppStatus ippiRGBToHSV_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppSize roiSize);
```

Supported values for `mod`:

- `8u_C3R`
- `16u_C3R`
- `8u_AC4R`
- `16u_AC4R`

**Include Files**

`ippcc.h`

**Domain Dependencies**

**Headers:** `ippcore.h`, `ippvm.h`, `ipps.h`, `ippi.h`

**Libraries:** `ippcore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`

**Parameters**

- `pSrc`  
  Pointer to the source image ROI.

- `srcStep`  
  Distance in bytes between starts of consecutive lines in the source image.

- `pDst`  
  Pointer to the destination image ROI.

- `dstStep`  
  Distance in bytes between starts of consecutive lines in the destination image.

- `roiSize`  
  Size of the source and destination ROI in pixels.

**Description**

This function operates with ROI (see **Regions of Interest in Intel IPP**).

This function converts the `R'G'B'` image `pSrc` to the `HSV` image `pDst`.

The conversion algorithm from `RGB` to `HSV` can be represented in pseudocode as follows:

```pseudocode
// Value: V = max(R,G,B); // Saturation: temp = min(R,G,B); if V = 0 then // achromatics
case S = 0 // chromatics case S = (V - temp)/V // Hue: Cr = (V - R) / (V - temp) Cg = (V - G) / (V - temp) Cb = (V - B) / (V - temp) if R = V then H = Cb - Cg if G = V then H = 2 + Cr - Cb if B = V then H = 4 + Cg - Cr H = 60*H if H < 0 then H = H + 360
```

The computed `H`, `S`, `V` values are scaled to the full range of the destination data type (see **Table “Image Data Types and Ranges”** in Chapter 2).

**Return Values**

- `ippStsNoErr`  
  Indicates no error. Any other value indicates an error.

- `ippStsNullPtrErr`  
  Indicates an error condition if `pSrc` or `pDst` is NULL.
Indicates an error condition if roiSize has a field with a zero or negative value.

**HSVToRGB**

*Converts an HSV image to the RGB color model.*

**Syntax**

IppStatus ippiHSVToRGB_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppSize roiSize);

**Supported values for mod:**

- 8u_C3R
- 16u_C3R
- 8u_AC4R
- 16u_AC4R

**Include Files**

ippcc.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h, ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**
  - Pointer to the source image ROI.
- **srcStep**
  - Distance in bytes between starts of consecutive lines in the source image.
- **pDst**
  - Pointer to the destination image ROI.
- **dstStep**
  - Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**
  - Size of the source and destination ROI in pixels.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts an **HSV image** pSrc to the image **R'G'B'pDst**.

The conversion algorithm from HSV to RGB can be represented in pseudocode as follows:

```
if S = 0 then    R = G = B = V else
    if H = 360 then    H = 0 else
        H = H/60
        I = floor(H)     M = V * ( 1 - S);
        F = H - I;       N = V * ( 1 - S * F);
        K = V * ( 1 - S * (1 - F));
        if(I == 0)then{ R = V;G = K;B = M;}    if(I == 1)then{ R = N;G = V;B = M;}    if(I == 2)then{ R = M;G = V;B = K;}    if(I == 3)then{ R = M;G = N;B = V;}    if(I == 4)then{ R = K;G = M;B = V;}    if(I == 5)then{ R = V;G = M;B = N;}
```

The computed **R'**, **G'**, **B'** values are scaled to the full range of the destination data type (see Table "Image Data Types and Ranges" in Chapter 2).

**Return Values**

- **ippStsNoErr**
  - Indicates no error. Any other value indicates an error.
RGBToYCoCg

Converts a RGB image to the YCoCg color model.

Syntax

IppStatusippiRGBToYCoCg_8u_C3P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep, IppiSize roi);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Array of pointers to the destination image ROI in each plane.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **roi**: Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts a RGB image \( pSrc \) to the YCoCg image \( pDst \) according to the following formulas:

\[
Y = \frac{(R + 2*G + B) + 2}{4}
\]

\[
Co = \frac{(R - B) + 1}{2}
\]

\[
Cg = \frac{( - R + 2*G - B) + 2}{4}
\]

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.

YCoCgToRGB

Converts a YCoCg image to the RGB image.
Syntax
IppStatus ippiYCoCgToRGB_8u_P3C3R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst, int dstStep, IppiSize roi);

Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
pSrc  Array of pointers to the source image ROI in each plane.
srcStep  Distance in bytes between starts of consecutive lines in the source image.
pDst  Pointer to the destination image ROI.
dstStep  Distance in bytes between starts of consecutive lines in the destination image.
roi  Size of the source and destination ROI in pixels.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the YCoCg image pSrc to the RGB image pDst according to the following formulas:
\[ R = Y + Co - Cg \]
\[ G = Y + Cg \]
\[ B = Y - Co - Cg \]

Return Values
ippStsNoErr  Indicates no error. Any other value indicates an error.
ippStsNullPtrErr  Indicates an error condition if one of the specified pointers is NULL.

BGRToYCoCg
Converts a 24-bit BGR image to the YCoCg color model.

Syntax
IppStatus ippiBGRToYCoCg_8u16s_C3P3R(const Ipp8u* pBGR, int bgrStep, Ipp16s* pYCC[3], int yccStep, IppiSize roiSize);
IppStatus ippiBGRToYCoCg_8u16s_C4P3R(const Ipp8u* pBGR, int bgrStep, Ipp16s* pYCC[3], int yccStep, IppiSize roiSize);

Include Files
ippcc.h
Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters

pBGR          Pointer to the source image ROI.
bgrStep       Distance in bytes between starts of consecutive lines in the
              source image.
pYCC          Array of pointers to the destination image ROI in each plane.
yccStep       Distance in bytes between starts of consecutive lines in the
              destination image.
roiSize       Size of the source and destination ROI in pixels.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the 24-bit BGR image pBGR to the YCoCg image pYCC according to the following formulas:
Y = ((R + 2*G + B) + 2)/4
Co = ((R - B) + 1)/2
Cg = (( - R + 2*G - B) + 2)/4

Return Values

ippStsNoErr   Indicates no error. Any other value indicates an error.
ippStsNullPtrErr   Indicates an error condition if one of the specified pointers is NULL.

SBGRToYCoCg

Converts a 48-bit BGR image to the YCoCg color model.

Syntax
IppStatus ippiSBGRToYCoCg_<mod>(const Ipp16s* pBGR, int bgrStep, Ipp<dstDatatype>* pYCC[3], int yccStep, IppiSize roiSize);

Supported values for mod:
16s_C3P3R       16s32s_C3P3R
16s_C4P3R       16s32s_C4P3R

Include Files
ippicc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib
Parameters

Parameter meanings:
- **pBGR**: Pointer to the source image ROI.
- **bgrStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pYCC**: Array of pointers to the destination image ROI in each plane.
- **yccStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**: Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 48-bit **BGR** image **pBGR** to the **YCoCg** image **pYCC** according to the following formulas:

\[
Y = \frac{(R + 2*G + B) + 2}{4}
\]

\[
Co = \frac{(R - B) + 1}{2}
\]

\[
Cg = \frac{(- R + 2*G - B) + 2}{4}
\]

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.

**YCoCgToBGR**

*Converts a YCoCg image to the 24-bit BGR image.*

Syntax

```c
IppStatus ippiYCoCgToBGR_16s8u_P3C3R(const Ipp16s* pYCC[3], int yccStep, Ipp8u* pBGR, int bgrStep, IppiSize roiSize);
IppStatus ippiYCoCgToBGR_16s8u_P3C4R(const Ipp16s* pYCC[3], int yccStep, Ipp8u* pBGR, int bgrStep, IppiSize roiSize, Ipp8u aval);
```

Include Files

```c
ippcc.h
```

Domain Dependencies

- **Headers**: ippcore.h, ippvm.h, ipps.h,ippi.h
- **Libraries**: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

Parameter meanings:
- **pYCC**: Array of pointers to the source image ROI in each plane.
- **yccStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pBGR**: Pointer to the destination image ROI.
**bgrStep**
Distance in bytes between starts of consecutive lines in the destination image.

**roiSize**
Size of the source and destination ROI in pixels.

**aval**
Constant value to create the fourth channel.

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the YCoCg image \( pYCC \) to the 24-bit BGR image \( pBGR \) according to the following formulas:

\[
R = Y + Co - Cg \\
G = Y + Cg \\
B = Y - Co - Cg
\]

The fourth channel is created by setting channel values to the constant value \( aval \).

**Return Values**
- **ippStsNoErr** Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr** Indicates an error condition if one of the specified pointers is NULL.

**YCoCgToSBGR**

*Converts a YCoCg image to the 48-bit BGR image.*

**Syntax**

**Case 1: Conversion to 3-channel image**

IppStatus ippiYCoCgToSBGR_16s_P3C3R(const Ipp16s* \( pYCC \)[3], int \( yccStep \), Ipp16s* \( pBGR \), int \( bgrStep \), IppiSize \( roiSize \));

IppStatus ippiYCoCgToSBGR_32s16s_P3C3R(const Ipp32s* \( pYCC \)[3], int \( yccStep \), Ipp16s* \( pBGR \), int \( bgrStep \), IppiSize \( roiSize \));

**Case 2: Conversion to 4-channel image**

IppStatus ippiYCoCgToSBGR_16s_P3C4R(const Ipp16s* \( pYCC \)[3], int \( yccStep \), Ipp16s* \( pBGR \), int \( bgrStep \), IppiSize \( roiSize \), Ipp16s \( aval \));

IppStatus ippiYCoCgToSBGR_32s16s_P3C4R(const Ipp32s* \( pYCC \)[3], int \( yccStep \), Ipp16s* \( pBGR \), int \( bgrStep \), IppiSize \( roiSize \), Ipp16s \( aval \));

**Include Files**
ippcc.h

**Domain Dependencies**

*Headers:* ippcore.h, ippvm.h, ipp.h

*Libraries:* ippcore.lib, ippvm.lib, ipp.lib, ippi.lib

**Parameters**

\( pYCC \) Array of pointers to the source image ROI in each plane.
**ipyccStep**  
Distance in bytes between starts of consecutive lines in the source image.

**pBGR**  
Pointer to the destination image ROI.

**bgrStep**  
Distance in bytes between starts of consecutive lines in the destination image.

**roiSize**  
Size of the source and destination ROI in pixels.

**aval**  
Constant value to create the fourth channel.

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the YCoCg image pYCC to the 48-bit BGR image pBGR according to the following formulas:

\[
R = Y + Co - Cg \\
G = Y + Cg \\
B = Y - Co - Cg
\]

The fourth channel is created by setting channel values to the constant value aval.

**Return Values**

- **ippStsNoErr**  
  Indicates no error. Any other value indicates an error.

- **ippStsNullPtrErr**  
  Indicates an error condition if one of the specified pointers is NULL.

**BGRToYCoCg_Rev**
*Converts a 24-bit BGR image to the YCoCg-R color model.*

**Syntax**

```c
IppStatus ippiBGRToYCoCg_Rev_8u16s_C3P3R(const Ipp8u* pBGR, int bgrStep, Ipp16s* pYCC[3], int yccStep, IppiSize roiSize);
IppStatus ippiBGRToYCoCg_Rev_8u16s_C4P3R(const Ipp8u* pBGR, int bgrStep, Ipp16s* pYCC[3], int yccStep, IppiSize roiSize);
```

**Include Files**

ippcc.h

**Domain Dependencies**
**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h  
**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pBGR**  
  Pointer to the source image ROI.

- **bgrStep**  
  Distance in bytes between starts of consecutive lines in the source image.
PyCC

yccStep

roiSize

Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 24-bit BGR image pSrc to the YCoCg-R image pDst according to the following formulas:
\[
\begin{align*}
C_o &= R - B \\
T &= B + (C_o >> 1) \\
C_g &= G - T \\
Y &= T + (C_g >> 1)
\end{align*}
\]

Return Values
ippStsNoErr Indicates no error. Any other value indicates an error.
ippStsNullPtrErr Indicates an error condition if one of the specified pointers is NULL.

SBGRToYCoCg_Rev
Converts a 48-bit BGR image to the YCoCg-R color model.

Syntax
IpplStatus ippiSBGRToYCoCg_Rev_<mod>(const Ipp16s* pBGR, int bgrStep, Ipp<dstDatatype>* pYCC[3], int yccStep, IppiSize roiSize);

Supported values for mod:
16s_C3P3R    16s32s_C3P3R
16s_C4P3R    16s32s_C4P3R

Include Files
ippcc.h

Parameters

pBGR Pointer to the source image ROI.
bgrStep Distance in bytes between starts of consecutive lines in the source image.
pYCC Array of pointers to the destination image ROI in each plane.
yccStep Distance in bytes between starts of consecutive lines in the destination image.
roiSize Size of the source and destination ROI in pixels.
Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 48-bit BGR image \( p_{BGR} \) to the YCoCg-R image \( p_{YCC} \) according to the following formulas:

\[
\begin{align*}
C_0 &= R - B \\
t &= B + (C_0 >> 1) \\
C_g &= G - t \\
Y &= t + (C_g >> 1)
\end{align*}
\]

Return Values
- **ippStsNoErr**: Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.

**YCoCgToBGR_Rev**
Converts a YCoCg-R image to the 24-bit BGR image.

Syntax

```c
IppStatus ippiYCoCgToBGR_Rev_16s8u_P3C3R(const Ipp16s* pYCC[3], int yccStep, Ipp8u* pBGR, int bgrStep, IppiSize roiSize);
IppStatus ippiYCoCgToBGR_Rev_16s8u_P3C4R(const Ipp16s* pYCC[3], int yccStep, Ipp8u* pBGR, int bgrStep, IppiSize roiSize, Ipp8u aval);
```

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters

- **pYCC**: Array of pointers to the source image ROI in each plane.
- **yccStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pBGR**: Pointer to the destination image ROI.
- **bgrStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**: Size of the source and destination ROI in pixels.
- **aval**: Constant value to create the fourth channel.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the YCoCg-R image \( p_{YCC} \) to the 24-bit BGR image \( p_{BGR} \) according to the following formulas:

\[
\begin{align*}
t &= Y - (Cg >> 1) \\
G &= Cg + t \\
B &= t - (Co >> 1) \\
R &= B + Co
\end{align*}
\]

The fourth channel is created by setting channel values to the constant value \( aval \).

**Return Values**

- ippStsNoErr: Indicates no error. Any other value indicates an error.
- ippStsNullPtrErr: Indicates an error condition if one of the specified pointers is NULL.

**YCoCgToSBGR_Rev**

*Converts a YCoCg-R image to the 48-bit BGR image.*

**Syntax**

**Case 1: Conversion to 3-channel image.**

```c
IppStatus ippiYCoCgToSBGR_Rev_16s_P3C3R(const Ipp16s* pYCC[3], int yccStep, Ipp16s* pBGR, int bgrStep, IppiSize roiSize);
IppStatus ippiYCoCgToSBGR_Rev_32s16s_P3C3R(const Ipp32s* pYCC[3], int yccStep, Ipp16s* pBGR, int bgrStep, IppiSize roiSize);
```

**Case 2: Conversion to 4-channel image**

```c
IppStatus ippiYCoCgToSBGR_Rev_16s_P3C4R(const Ipp16s* pYCC[3], int yccStep, Ipp16s* pBGR, int bgrStep, IppiSize roiSize, Ipp16s aval);
IppStatus ippiYCoCgToSBGR_Rev_32s16s_P3C4R(const Ipp32s* pYCC[3], int yccStep, Ipp16s* pBGR, int bgrStep, IppiSize roiSize, Ipp16s aval);
```

**Include Files**

ippcc.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h, ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

**Parameters**

- \( p_{YCC} \): Array of pointers to the source image ROI in each plane.
- \( yccStep \): Distance in bytes between starts of consecutive lines in the source image.
- \( p_{BGR} \): Pointer to the destination image ROI.
- \( bgrStep \): Distance in bytes between starts of consecutive lines in the destination image.
- \( roiSize \): Size of the source and destination ROI in pixels.
aval

Constant value to create the fourth channel.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the YCoCg-R image pYCC to the 48-bit BGR image pBGR according to the following formulas:
\[ t = Y - (Cg >> 1) \]
\[ G = Cg + t \]
\[ B = t - (Co >> 1) \]
\[ R = B + Co \]
The fourth channel is created by setting channel values to the constant value \( aval \).

Return Values
ippStsNoErr Indicates no error. Any other value indicates an error.
ippStsNullPtrErr Indicates an error condition if one of the specified pointers is NULL.

Color - Gray Scale Conversions

GrayToRGB

Converts a gray scale image to RGB/BGR by copying luminance component to color components.

Syntax
IppStatus ippiGrayToRGB_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for \( \text{mod} \):
- 8u_C1C3R
- 16u_C1C3R
- 32f_C1C3R
- 8u_C1C4R
- 16u_C1C4R
- 32f_C1C4R

Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
 Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib
Parameters

pSrc
Pointer to the source image ROI.

srcStep
Distance, in bytes, between the starting points of consecutive lines in the source image.

pDst
Pointer to the destination image ROI.

dstStep
Distance, in bytes, between the starting points of consecutive lines in the destination image.

roiSize
Size of the source and destination ROI, in pixels.

aval
Constant value to create the fourth channel.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts a gray scale image to an RGB/BGR image by copying luminance component to color components.

Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error.

ippStsNullPtrErr
Indicates an error when pSrc or pDst is NULL.

ippStsSizeErr
Indicates an error condition if roiSize has a field with a zero or negative value.

Example

The code example below demonstrates how to use the ippiGrayToRGB_8u_C1C4R function.

```c
const int WIDTH = 2;
const int HEIGHT = 1;

Ipp8u pSrc[WIDTH * HEIGHT] = {
    113, 113,
};
Ipp8u pDst[WIDTH * HEIGHT * 4];
int srcStep = WIDTH, dstStep = WIDTH * 4;
IppiSize roiSize = {WIDTH, HEIGHT};
IppSts status = ippiGrayToRGB_8u_C1C4R(pSrc, srcStep, pDst, dstStep, roiSize, 0xFF);
if ( status == ippStsNoErr) {
    printf("PASS: (%3d %3d %3d %3d), (%3d %3d %3d %3d)\n", pDst[0], pDst[1], pDst[2], pDst[3], pDst[4], pDst[5], pDst[6], pDst[7]);
} else
    printf("FAIL: status = %d\n", status);
```

Result:

PASS:
(113 113 113 255), (113 113 113 255)

See Also

Regions of Interest in Intel IPP
RGBToGray
Converts an RGB image to gray scale using fixed transform coefficients.

Syntax
IppStatus ippiRGBToGray_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:
8u_C3C1R    16u_C3C1R    16s_C3C1R    32f_C3C1R
8u_AC4C1R   16u_AC4C1R   16s_AC4C1R   32f_AC4C1R

Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
pSrc
Pointer to the source image ROI.
srcStep
Distance in bytes between starts of consecutive lines in the source image.
pDst
Pointer to the destination image ROI.
dstStep
Distance in bytes between starts of consecutive lines in the destination image.
roiSize
Size of the source and destination ROI in pixels.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
Conversion from RGB image to gray scale (see figure Converting an RGB Image to Gray Scale) uses the following basic equation to compute luma from nonlinear gamma-corrected red, green, and blue values: Y' = 0.299 * R' + 0.587 * G' + 0.114 * B'. Note that the transform coefficients conform to the standard for the NTSC red, green, and blue CRT phosphors.

Converting an RGB Image to Gray Scale

![Converting an RGB Image to Gray Scale](image)
Return Values

ippStsNoErr     Indicates no error. Any other value indicates an error.
ippStsNullPtrErr Indicates an error condition if pSrc or pDst pointer is NULL.
ippStsSizeErr   Indicates an error condition if roiSize has a field with a zero or negative value.

Example

The code example below demonstrates how to use the function ippiRGBToGray_8u_C3C1R.

```c
Ipp8u src[12*3] = { 255, 0, 0, 255, 0, 0, 255, 0, 0, 255, 0, 0,
                  0, 255, 0, 0, 255, 0, 0, 255, 0, 0, 255, 0, 0,
                  0, 0, 255, 0, 0, 255, 0, 0, 255, 0, 0, 255};
Ipp8u dst[4*3];
IppiSize srcRoi = { 4, 3 }; 
ippiRGBToGray_8u_C3C1R ( src, 12, dst, 4, srcRoi );
```

Result:

```
255 0   0   255 0   0   255 0   0   255 0   0   255 0   0
0   255 0   0   255 0   0   255 0   0   255 0   0
0   0   255 0   0   255 0   0   255 0   0   255 0

76 76 76 76 
149 149 149 149 dst
29 29 29 29
```

ColorToGray

Converts an RGB image to gray scale using custom transform coefficients.

Syntax

```c
IppStatus ippiColorToGray_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp32f coeffs[3]);
```

Supported values for mod:

8u_C3C1R  16u_C3C1R  16s_C3C1R  32f_C3C1R
8u_AC4C1R 16u_AC4C1R 16s_AC4C1R 32f_AC4C1R

```c
IppStatus ippiColorToGray_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp64f coeffs[3]);
```

Supported values for mod:

64f_C3C1R
64f_AC4C1R

Include Files

ippcc.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc
Pointer to the source image ROI.
srcStep
Distance in bytes between starts of consecutive lines in the source image.
pDst
Pointer to the destination image ROI.
dstStep
Distance in bytes between starts of consecutive lines in the destination image.
roiSize
Size of the source and destination ROI in pixels.
coeffs
Transform coefficients.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function uses the following equation to convert an RGB image to gray scale:

\[ Y = coeffs[0] \times R + coeffs[1] \times G + coeffs[2] \times B, \]

where the \( coeffs \) array contains user-defined transform coefficients which must be non-negative and satisfy the condition

\[ coeffs[0] + coeffs[1] + coeffs[2] \leq 1. \]

Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error.
ippStsNullPtrErr
Indicates an error condition if pSrc or pDst is NULL.
ippStsSizeErr
Indicates an error condition if roiSize has a field with a zero or negative value.

CFAToBGRA

Restores the RGB image from the gray-scale CFA image using the VNG algorithm.

Syntax

IppStatus ippCFAToBGRA_VNG_8u_C1C4R(const Ipp8u* pSrc, IppiRect srcRoi, IppiSize srcSize, int srcStep, Ipp32f scale[4], Ipp8u* pDst, int dstStep, IppiBayerGrid grid);
IppStatus ippCFAToBGRA_VNG_16u_C1C4R(const Ipp16u* pSrc, IppiRect srcRoi, IppiSize srcSize, int srcStep, Ipp32f scale[4], Ipp16u* pDst, int dstStep, IppiBayerGrid grid);
IppStatus ippCFAToBGRA_VNG_8u_C1C4R_L(const Ipp8u* pSrc, IppiRectL srcRoiL, IppiSizeL srcSizeL, IppSizeL srcStepL, Ipp32f scale[4], Ipp8u* pDst, IppSizeL dstStepL, IppiBayerGrid grid);
IppStatus ippiCFAToBGRA_VNG_16u_C1C4R_L(const Ipp16u* pSrc, IppiRectL srcRoiL, IppiSizeL srcSizeL, IppiSizeL srcStepL, Ipp32f scale[4], Ipp16u* pDst, IppiSizeL dstStepL, IppiBayerGrid grid);

Include Files
ippcc.h
ippcc_l.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
pSrc
Region of interest in the source image.

srcRoi, srcRoiL
Region of interest in the source image (of the IppiRect or IppiRectL type).

srcSize, srcSizeL
Size of the source image.

srcStep, srcStepL
Distance, in bytes, between the starting points of consecutive lines in the source image.

scale[4]
Coefficients by which the resulting RGB channels are multiplied after interpolation. By default, equal to 1.0.

pDst
Pointer to the destination image.

dstStep, dstStepL
Distance, in bytes, between the starting points of consecutive lines in the destination image.

grid
Specifies the configuration of the Bayer grid in the source image. The function copies 2-pixel width border pixels from the internal neighborhood pixels. The following values are possible:
ippiBayerBGGR
ippiBayerRGGB
ippiBayerGBRG
ippiBayerGRBG

Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function transforms the one-channel gray-scale image pSrc that is produced by applying the color filter array (CFA) to 24-bit three-channel RGB image using the Variable Number of Gradients (VNG) demosaicing algorithm.

Return Values
ippStsNoErr
Indicates no error. Any other value indicates an error.

ippStsNullPtrErr
Indicates an error condition if one of the specified pointers is NULL.
Indicates an error condition if the `srcSize` or `srcSizeL` has a field that is less than 2, or if the `srcRoi` or `srcRoiL` has a field with a negative or zero value.

Indicates an error condition if `grid` has an illegal value.

**See Also**
Structures and Enumerators
Structures and Enumerators for Platform-Aware Functions

**CFAToRGB**
Restores the RGB image from the gray-scale CFA image.

**Syntax**

```c
IppStatus ippiCFAToRGB_8u_C1C3R(const Ipp8u* pSrc, IppiRect srcRoi, IppiSize srcSize, int srcStep, Ipp8u* pDst, int dstStep, IppiBayerGrid grid, int interpolation);
IppStatus ippiCFAToRGB_16u_C1C3R(const Ipp16u* pSrc, IppiRect srcRoi, IppiSize srcSize, int srcStep, Ipp16u* pDst, int dstStep, IppiBayerGrid grid, int interpolation);
```

**Include Files**
ippcc.h

**Domain Dependencies**
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

**Parameters**

- **pSrc**
  Pointer to the source image origin.

- **srcSize**
  Size of the source image.

- **srcRoi**
  Region of interest in the source image (of the `IppiRect` type).

- **srcStep**
  Distance in bytes between starts of consecutive lines in the source image.

- **pDst**
  Pointer to the destination image.

- **dstStep**
  Distance in bytes between starts of consecutive lines in the destination image.

- **grid**
  Specifies the configuration of the Bayer grid in the source image. The following values are possible:
  - ippiBayerBGGR
  - ippiBayerRGGB
  - ippiBayerGBRG
  - ippiBayerGRBG

- **interpolation**
  Interpolation method, reserved, must be 0.
Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function transforms the one-channel gray-scale image pSrc that is produced by applying the color filter array (CFA) - an array of Bayer filters, to 24-bit three-channel RGB image. The order of the color component in the source image - Bayer grid - is specified by the parameter grid. Four possible values of this parameter correspond to the allowed variants of the Bayer grid (see Figure below).

Possible Configurations of the Bayer Grids

| BGGR | RGGB | GBRG | GRBG |

Each element of the source image contains an intensity value for only one color component, two others are interpolated using neighbor elements. R and B values are interpolated linearly from the nearest neighbors of the same color. When interpolating R and B values on green pixel, the average values of the two nearest neighbors (above and below, or left and right) of the same colors are used. When interpolating R or B values on the blue or red pixel respectively, the average values of the four nearest blue (red) pixels cornering the red (blue) pixel are used. G values are interpolated using an adaptive interpolation [Sak98] from a pair of nearest neighbors (vertical or horizontal) and taking into account the correlation in the red (or blue) component. The pair is chosen depending on the values of the difference between the red (blue) pixels in the vertical and horizontal directions. If the difference is smaller in the vertical direction - a vertical pair of green pixels is used, if it is smaller in the horizontal direction - a horizontal pair is used. If the difference is the same, all four neighbors are used.

This interpolation requires border pixels for the input pixels near the horizontal or vertical edge of the image. The function uses the mirrored border of two edge rows or columns of the input image. In this case the G values is calculated as the average of four nearest green pixels.

Return Values

<table>
<thead>
<tr>
<th>Status Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error condition if one of the specified pointer is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error condition if the srcSize has a field that is less than 2, or if the roiSize has a field with negative or zero value.</td>
</tr>
<tr>
<td>ippStsBadArgErr</td>
<td>Indicates an error condition if grid has an illegal value.</td>
</tr>
</tbody>
</table>

DemosaicAHD

Restores the RGB image from the gray-scale CFA image using AHD algorithm.

Syntax

IppStatus ippiDemosaicAHD_8u_C1C3R(const Ipp8u* pSrc, IppiRect srcRoi, IppiSize srcSize, int srcStep, Ipp8u* pDst, int dstStep, IppiBayerGrid grid, Ipp8u* pTmp, int tmpStep);
IppStatus ippiDemosaicAHD_16u_C1Cl3R(const Ipp16u* pSrc, IppiRect srcRoi, IppiSize srcSize, int srcStep, Ipp16u* pDst, int dstStep, IppiBayerGrid grid, Ipp16u* pTmp, int tmpStep);

Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc
Pointer to the source image.

srcRoi
Region of interest in the source image (of the IppiRect type).

srcSize
Size of the source image.

srcStep
Distance in bytes between starts of consecutive lines in the source image.

pDst
Pointer to the destination image.

dstStep
Distance in bytes between starts of consecutive lines in the destination image.

grid
Specifies the configuration of the Bayer grid in the source image. The following values are possible (see Figure Possible Configurations of the Bayer Grids):

ippiBayerBGGR
ippiBayerRGGB
ippiBayerGBRG
ippiBayerGRBG

pTmp
Pointer to the temporary image of (srcRoi.width + 6, 30) size.

tmpStep
Distance in bytes between starts of consecutive lines in the temporary image.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function transforms the one-channel gray-scale image pSrc that is produced by applying the color filter array (CFA) to 24-bit three-channel RGB image using the adaptive homogeneity-directed demosaicing (AHD) algorithm [Hir05]. The algorithm requires the temporary image pTmp of size srcRoi.width +6.30.

The type of the Bayer grid (see Figure Possible Configurations of the Bayer Grids) is specified by the parameter grid.

Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error.

ippStsNullPtrErr
Indicates an error condition if one of the specified pointer is NULL.
Indicates an error condition if the srcSize has a field that is less than 5, or if the roiSize has a field with negative or zero value.

Indicates an error condition if grid has an illegal value.

**Format Conversion**

This section describes Intel IPP functions that perform image color conversion without changing the color space. These functions convert pixel-order images to planar format and vice versa, change the number of channels or planes, alter sampling formats and sequences of samples and planes. Several functions additionally perform filtering – deinterlacing and upsampling.

Intel IPP format conversion functions are specified mainly in the YCbCr color space, but as they do not transform color model they may be used to perform described types of conversion for any other color spaces with decoupled luminance and chrominance coordinates (YUV type).

**YCbCr422**

*Converts 4:2:2 YCbCr image.*

**Syntax**

```c
IppStatus ippiYCbCr422_8u_C2P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiYCbCr422_8u_P3C2R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);
```

**Include Files**

ippcc.h

**Domain Dependencies**

*Headers:* ippcore.h, ippvm.h, ipps.h,ippi.h
*Libraries:* ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>pSrc</code></td>
<td>Pointer to the ROI in the pixel-order source image. Array of pointers to the ROI in each plane of the planar source image.</td>
</tr>
<tr>
<td><code>srcStep</code></td>
<td>Distance in bytes between starts of consecutive lines in the source image. Array of distance values for the source image planes.</td>
</tr>
<tr>
<td><code>pDst</code></td>
<td>Pointer to the ROI in the pixel-order destination image. Array of pointers to the ROI in each plane of the planar destination image.</td>
</tr>
<tr>
<td><code>dstStep</code></td>
<td>Distance in bytes between starts of consecutive lines in the destination image. Array of distance values for the destination image planes.</td>
</tr>
<tr>
<td><code>roiSize</code></td>
<td>Size of the source and destination ROI in pixels.</td>
</tr>
</tbody>
</table>

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the 4:2:2 two-channel source image \textit{pSrc} to the 4:2:2 three-plane image \textit{pDst} and vice versa (see Table "Pixel-Order Image Formats" and Table "Planar Image Formats" for more details on 4:2:2 planar and pixel-order formats).

Return Values

- \texttt{ippStsNoErr}  
  Indicates no error. Any other value indicates an error.
- \texttt{ippStsNullPtrErr}  
  Indicates an error condition if any of the specified pointers is NULL.
- \texttt{ippStsSizeErr}  
  Indicates an error condition if \textit{roiSize.width} of the first plane is less than 2, or \textit{roiSize.height} is less than or equal to zero.

\textbf{YCbCr422ToYCrCb422}

\textit{Converts 4:2:2 YCbCr image to 4:2:2 YCrCb image.}

Syntax

\begin{verbatim}
IppStatus ippiYCbCr422ToYCrCb422_8u_C2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiYCbCr422ToYCrCb422_8u_P3C2R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);
\end{verbatim}

Include Files

\texttt{ippcc.h}

Domain Dependencies

Headers: \texttt{ippcore.h, ippvm.h, ipps.h,ippi.h}

Libraries: \texttt{ippcore.lib, ippvm.lib, ipps.lib,ippi.lib}

Parameters

- \textit{pSrc}  
  Pointer to the ROI in the pixel-order source image. Array of pointers to the ROI in each plane of the planar source image.
- \textit{srcStep}  
  Distance in bytes between starts of consecutive lines in the source image. Array of distance values for the source image planes.
- \textit{pDst}  
  Pointer to the destination image ROI.
- \textit{dstStep}  
  Distance in bytes between starts of consecutive lines in the destination image.
- \textit{roiSize}  
  Size of the ROI in pixels, its width should be multiple of 2.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts 4:2:2YCbCr source image \textit{pSrc} to the 4:2:2 YCrCb two-channel image \textit{pDst} that has the following sequence of samples: Y0, Cr0, Y1, Cb0, Y2, Cr1, Y3, Cb1, ... (see Table "Pixel-Order Image Formats"). The source image can be either two-channel or three-plane (see Table "Pixel-Order Image Formats" and Table "Planar Image Formats").
Return Values

ippStsNoErr  
Indicates no error. Any other value indicates an error.

ippStsNullPtrErr  
Indicates an error condition if any of the specified pointers is NULL.

ippStsSizeErr  
Indicates an error condition if roiSize.width is less than 2.

YCbCr422ToCbYCr422  
Converts 4:2:2 YCbCr image to 4:2:2 CbYCr image.

Syntax

IppStatus ippiYCbCr422ToCbYCr422_8u_C2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);

IppStatus ippiYCbCr422ToCbYCr422_8u_P3C2R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc  
Pointer to the ROI in the pixel-order source image. Array of pointers to the ROI in each plane of the planar source image.

srcStep  
Distance in bytes between starts of consecutive lines in the source image. Array of distance values for the source image planes.

pDst  
Pointer to the destination image ROI.

dstStep  
Distance in bytes between starts of consecutive lines in the destination image.

roiSize  
Size of the source and destination ROI in pixels; its width should be multiple of 2.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts 4:2:2 YCbCr source image pSrc to the 4:2:2 CbYCr two-channel image pDst that has the following sequence of samples: Cb0, Y0, Cr0, Y1, Cb1, Y2, Cr1, Y3, Cb3, ... (see Table “Pixel-Order Image Formats”). The source image can be either two-channel or three-plane (see Table “Pixel-Order Image Formats” and Table “Planar Image Formats”).

Return Values

ippStsNoErr  
Indicates no error. Any other value indicates an error.

ippStsNullPtrErr  
Indicates an error condition if any of the specified pointers is NULL.
ippStsSizeErr Indicates an error condition if roiSize.width of the first plane is less than 2, or roiSize.height is less than or equal to zero.

**YCbCr422ToYCbCr420**

Converts YCbCr image from 4:2:2 sampling format to 4:2:0 format.

**Syntax**

**Case 1: Operation on planar data**

IppStatus ippiYCbCr422ToYCbCr420_8u_P3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

IppStatus ippiYCbCr422ToYCbCr420_8u_P3P2R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDstY, int dstYStep, Ipp8u* pDstCbCr, int dstCbCrStep, IppiSize roiSize);

**Case 2: Conversion from pixel-order to planar data**

IppStatus ippiYCbCr422ToYCbCr420_8u_C2P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

IppStatus ippiYCbCr422ToYCbCr420_8u_C2P2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDstY, int dstYStep, Ipp8u* pDstCbCr, int dstCbCrStep, IppiSize roiSize);

**Include Files**

ippcc.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h, ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

**Parameters**

**pSrc**

Pointer to the ROI in the pixel-order source image. Array of pointers to the ROI in each plane of the planar source image.

**srcStep**

Distance in bytes between starts of consecutive lines in the source image. Array of distance values for the source image planes.

**pDst**

Array of pointers to the ROI in each plane for a three-plane destination image.

**dstStep**

Array of distances in bytes between starts of consecutive lines in each plane for a three-plane destination image.

**pDstY**

Pointer to the ROI in the luminance plane for a two-plane destination image.

**dstYStep**

Distance in bytes between starts of consecutive lines in the luminance plane of a destination image.

**pDstCbCr**

Pointer to the ROI in the interleaved chrominance plane for a two-plane destination image.

**dstCbCrStep**

Distance in bytes between starts of consecutive lines in the chrominance plane of a destination image.

**roiSize**

Size of the ROI in pixels, height and width should be multiple of 2.
Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:2:2 image pSrc to the 4:2:0 image. The source image can be two-channel or three-plane, destination image always is planar with two or three planes (see Table "Pixel-Order Image Formats" and Table "Planar Image Formats"). Two-plane image contains luminance samples Y0, Y1, Y2, .. in the first plane pDstY, and interleaved chrominance samples Cb0, Cr0, Cb1, Cr1, ... in the second plane pDstCbCr.

Return Values
ippStsNoErr Indicates no error. Any other value indicates an error.
ippStsNullPtrErr Indicates an error condition if any of the specified pointers is NULL.
ippStsSizeErr Indicates an error condition if any field of the roiSize is less than 2.

Example
The code example below shows how to use the function ippiYCbCr422ToYCbCr420_8u_C2P3R.

```cpp

// Initialize variables
Ipp8u* ImageI420[3];
int stepI420[3];
Ipp8u* ImageYUY2;
int stepYUY2;
IppiSize roiSize = { 1024, 768};

ImageI420[0] = ippiMalloc_8u_C1( roiSize.width, roiSize.height, &(stepI420[0]));
ImageI420[1] = ippiMalloc_8u_C1( roiSize.width, roiSize.height, &(stepI420[1]));
ImageYUY2 = ippiMalloc_8u_C2( roiSize.width, roiSize.height, &stepYUY2 );
ippiYCbCr422ToYCbCr420_8u_C2P3R( ImageYUY2, stepYUY2, ImageI420, stepI420, roiSize);

ippiFree(ImageI420[0]);
ippiFree(ImageI420[1]);
ippiFree(ImageI420[2]);
ippiFree(ImageYUY2);
```

YCbCr422To420_Interlace
Converts interlaced YCbCr image from 4:2:2 sampling format to 4:2:0 format.

Syntax
IppStatus ippiYCbCr422To420_Interlace_8u_P3R(const Ipp8u* pSrc[3], int srcStep[3],
Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Parameters

- **pSrc**: Array of pointers to the ROI in each plane for source image.
- **srcStep**: Array of distances in bytes between starts of consecutive lines in each plane for the source image.
- **pDst**: Array of pointers to the ROI in each plane for destination image.
- **dstStep**: Array of distances in bytes between starts of consecutive lines in each plane for destination image.
- **roiSize**: Size of the source and destination ROI in pixels, its width must be multiple of 2, and height must be multiple of 4.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the interlaced 4:2:2 image `pSrc` to the 4:2:0 image `pDst` (see Table "Planar Image Formats").

The conversion is performed in accordance with the following formulas:

\[
Y_{dest} = Y_{src}; \\
Cb_0(Cr_0)_{dest} = \frac{(3*Cb_0(Cr_0)_{src} + Cb_2(Cr_2)_{src} + 2)}{4}; \\
Cb_1(Cr_1)_{dest} = \frac{(Cb_1(Cr_1)_{src} + 3*Cb_3(Cr_3)_{src} + 2)}{4};
\]

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**: Indicates an error condition if any of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if `roiSize.width` is less than 2, or `roiSize.height` is less than 4.
- **ippStsDoubleSize**: Indicates a warning if `roiSize.width` is not multiple of 2, or `roiSize.height` is not multiple of 4.

**YCbCr422ToYCrCb420**

Converts 4:2:2 YCbCr image to 4:2:0 YCrCb image.

Syntax

IppStatus ippiYCbCr422ToYCrCb420_8u_C2P3R(const Ipp8u* `pSrc`, int `srcStep`, Ipp8u* `pDst`[3], int `dstStep[3]`, IppiSize `roiSize`);

IppStatus ippiYCbCr422ToYCrCb420_8u_C2P2R(const Ipp8u* `pSrc`, int `srcStep`, Ipp8u* `pDstY`, int `dstYStep`, Ipp8u* `pDstCrCb`, int `dstUVStep`, IppiSize `roiSize`);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Parameters

- **pSrc**
  Pointer to the source image ROI.

- **srcStep**
  Distance in bytes between starts of consecutive lines in the source image.

- **pDst**
  Array of pointers to the ROI in each plane of the destination image.

- **pDstY**
  Pointer to the destination image Y plane.

- **dstStep**
  Array of distances, in bytes, between the starting points of consecutive lines in the destination image planes.

- **dstYStep**
  Array of distances, in bytes, between the starting points of consecutive lines in the destination image Y plane.

- **dstUVStep**
  Array of distances, in bytes, between the starting points of consecutive lines in the destination image UV plane.

- **roiSize**
  Size of the source and destination ROI in pixels, height and width should be multiple of 2.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:2:2 two-channel image `pSrc` that has the following sequence of samples: `Y0, Cb0, Y1, Cr0, Y2, Cb1, Y3, Cr1, ...` to the 4:2:0 three-plane image `pDst` with the following order of pointers: Y-plane, Cr-plane, Cb-plane (see Table “Pixel-Order Image Formats” and Table “Planar Image Formats”).

Return Values

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error.

- **ippStsNullPtrErr**
  Indicates an error condition if any of the specified pointers is NULL.

- **ippStsSizeErr**
  Indicates an error condition if any field of the `roiSize` is less than 2.

**YCbCr422ToYCbCr411**

Converts YCbCr image from 4:2:2 sampling format to 4:1:1 format.

Syntax

**Case 1: Operation on planar data**

```c
IppStatus ippiYCbCr422ToYCbCr411_8u_P3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiYCbCr422ToYCbCr411_8u_P3P2R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDstY, int dstYStep, Ipp8u* pDstCbCr, int dstCbCrStep, IppiSize roiSize);
```

**Case 2: Conversion from pixel-order to planar data**

```c
IppStatus ippiYCbCr422ToYCbCr411_8u_C2P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiYCbCr422ToYCbCr411_8u_C2P2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDstY, int dstYStep, Ipp8u* pDstCbCr, int dstCbCrStep, IppiSize roiSize);
```
Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc  Pointer to the ROI in the pixel-order source image. Array of
      pointers to the ROI in each plane of the planar source image.
srcStep  Distance in bytes between starts of consecutive lines in the
      source image. Array of distance values for the source image
      planes.

pDst  Array of pointers to the ROI in each plane for a three-plane
      destination image.
dstStep  Array of distances in bytes between starts of consecutive lines
      in each plane for a three-plane destination image.
pDstY  Pointer to the ROI in the luminance plane for a two-plane
      destination image.
dstYStep  Distance in bytes between starts of consecutive lines in the
      luminance plane of a destination image.
pDstCbCr  Pointer to the ROI in the interleaved chrominance plane for a
       two-plane destination image.
dstCbCrStep  Distance in bytes between starts of consecutive lines in the
      chrominance plane of a destination image.
roiSize  Size of the ROI in pixels.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the 4:2:2 image pSrc to the 4:1:1 image. The source image can be two-channel or
three-plane (see Table "Pixel-Order Image Formats" for more details), destination image always is planar
with two or three planes (see Table "Planar Image Formats" for more details). The two-plane image contains
luminance samples Y0, Y1, Y2, .. in the first plane pDstY, and interleaved chrominance samples Cb0, Cr0,
Cb1, Cr1, ... in the second plane pDstCbCr.
The value of the fields of the roiSize have certain limitations:
- its width should be multiple of 4 and cannot be less than 4 for operation on two-channel images;
- its width should be multiple of 4 and cannot be less than 4, and its height should be multiple of 2 and can
  not be less than 2 for three-plane to two-plane image conversion;
- both height and width should be multiple of 2 and cannot be less than 2 for operation on three-plane
  images.

Return Values

ippStsNoErr  Indicates no error. Any other value indicates an error.
ippStsNullPtrErr  Indicates an error condition if any of the specified pointers is
      NULL.
Indicates an error condition if corresponding fields of the `roiSize` is less than specified above values.

**YCrCb422ToYCbCr422**

*Converts 4:2:2 YCrCb image to 4:2:2 YCbCr image.*

**Syntax**

```c
IppStatus ippiYCrCb422ToYCbCr422_8u_C2P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
```

**Include Files**

`ippcc.h`

**Domain Dependencies**

**Headers:** `ippcore.h, ippvm.h, ipps.h,ippi.h`

**Libraries:** `ippcore.lib, ippvm.lib, ipps.lib,ippi.lib`

**Parameters**

- `pSrc`  
  Pointer to the source image ROI.
- `srcStep`  
  Distance in bytes between starts of consecutive lines in the source image.
- `pDst`  
  Array of pointers to the ROI in each plane of the destination image.
- `dstStep`  
  Array of distances in bytes between starts of consecutive lines in the destination image planes.
- `roiSize`  
  Size of the ROI in pixels, its width should be multiple of 2.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:2:2 YCrCb two-channel image `pSrc` (see Table “Pixel-Order Image Formats”) to the 4:2:2 YCbCr three-plane image `pDst` (see Table “Planar Image Formats”).

**Return Values**

- `ppStsNoErr`  
  Indicates no error. Any other value indicates an error.
- `ippStsNullPtrErr`  
  Indicates an error condition if any of the specified pointers is NULL.
- `ippStsSizeErr`  
  Indicates an error condition if `roiSize.width` is less than 2.

**YCrCb422ToYCbCr420**

*Converts 4:2:2 YCrCb image to 4:2:0 YCbCr image.*

**Syntax**

```c
IppStatus ippiYCrCb422ToYCbCr420_8u_C2P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
```
Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- **pSrc**
  Pointer to the source image ROI.

- **srcStep**
  Distance in bytes between starts of consecutive lines in the source image.

- **pDst**
  Array of pointers to the ROI in each plane of the destination image.

- **dstStep**
  Array of distances in bytes between starts of consecutive lines in the destination image planes.

- **roiSize**
  Size of the ROI in pixels, height and width should be multiple of 2.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:2:2YCrCb two-channel image **pSrc** (see Table “Pixel-Order Image Formats”) to the 4:2:0YCbCr three-plane image **pDst** (see Table “Planar Image Formats”).

Return Values

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error.

- **ippStsNullPtrErr**
  Indicates an error condition if any of the specified pointers is NULL.

- **ippStsSizeErr**
  Indicates an error condition if any field of the **roiSize** is less than 2.

**YCrCb422ToYCbCr411**
 Converts 4:2:2 YCrCb image to 4:1:1 YCbCr image.

Syntax

IppStatus ippiYCrCb422ToYCbCr411_8u_C2P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Parameters

**pSrc**
Pointer to the source image ROI.

**srcStep**
Distance in bytes between starts of consecutive lines in the source image.

**pDst**
Array of pointers to the ROI in each plane of the destination image.

**dstStep**
Array of distances in bytes between starts of consecutive lines in the destination image planes.

**roiSize**
Size of the ROI in pixels, its width should be multiple of 4.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:2:2YCrCb two-channel image **pSrc** (see Table "Pixel-Order Image Formats") to the 4:1:1YCbCr three-plane image **pDst** (see Table "Planar Image Formats").

Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error condition if any of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error condition if roiSize.width is less than 4.</td>
</tr>
</tbody>
</table>

**CbYCr422ToYCbCr422**

Converts 4:2:2 CbYCr image to 4:2:2 YCbCr image.

Syntax

```c
IppStatus ippiCbYCr422ToYCbCr422_8u_C2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiCbYCr422ToYCbCr422_8u_C2P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
```

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

**pSrc**
Pointer to the source image ROI.

**srcStep**
Distance in bytes between starts of consecutive lines in the source image.

**pDst**
Pointer to the ROI in the pixel-order destination image. Array of pointers to the ROI in each plane of the planar destination image.
**dstStep**
Distance in bytes between starts of consecutive lines in the destination image. Array of distance values for the destination image planes.

**roiSize**
Size of the ROI in pixels, its width should be multiple of 2.

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:2:2 CbYCr two-channel image pSrc to the 4:2:0 YCbCr two-channel or three-plane image pDst (see Table "Pixel-Order Image Formats" and Table "Planar Image Formats"). The source image has the following sequence of samples: Cb0, Y0, Cr0, Y1, Cb1, Y2, Cr1, Y3, Cb2, ... . Two-channel destination image has different sequence of samples: Y0, Cb0, Y1, Cr0, Y2, Cb1, Y3, Cr1, Y4, ....

**Return Values**
- **ppStsNoErr**
  Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**
  Indicates an error condition if any of the specified pointers is NULL.
- **ippStsSizeErr**
  Indicates an error condition if roiSize.width is less than 2.

**CbYCr422ToYCbCr420**
Converts 4:2:2 CbYCr image to 4:2:0 YCbCr image.

**Syntax**

```c
IppStatus ippiCbYCr422ToYCbCr420_8u_C2P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
```

```c
IppStatus ippiCbYCr422ToYCbCr420_8u_C2P2R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDstY, int dstYStep, Ipp8u* pDstCbCr, int dstCbCrStep, IppiSize roiSize);
```

**Include Files**
ippcc.h

**Domain Dependencies**
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**
- **pSrc**
  Pointer to the source image ROI.
- **srcStep**
  Distance in bytes between starts of consecutive lines in the source image.
- **pDst**
  Array of pointers to the ROI in each plane for a three-plane destination image.
- **dstStep**
  Array of distances in bytes between starts of consecutive lines in each plane for a three-plane destination image.
- **pDstY**
  Pointer to the ROI in the luminance plane for a two-plane destination image.
dstYStep
Distance in bytes between starts of consecutive lines in the luminance plane of a destination image.

pDstCbCr
Pointer to the ROI in the interleaved chrominance plane for a two-plane destination image.

dstCbCrStep
Distance in bytes between starts of consecutive lines in the chrominance plane of a destination image.

roiSize
Size of the source and destination ROI in pixels, height and width should be multiple of 2.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:2:2CbYCr two-channel image pSrc to the 4:2:0YCbCr two- or three-plane image pDst (see Table "Pixel-Order Image Formats" and Table "Planar Image Formats"). The source image has the following sequence of samples: Cb0, Y0, Cr0, Y1, Cb1, Y2, Cr1, Y3, Cb2, ... Three-plane destination image has the following order of pointers: Y-plane, Cb-plane, Cr-plane. Two-plane destination image contains luminance samples Y0, Y1, Y2, ... in the first plane pDstY, and interleaved chrominance samples Cb0, Cr0, Cb1, Cr1, ... in the second plane pDstCbCr.

Return Values
ippStsNoErr
Indicates no error. Any other value indicates an error.

ippStsNullPtrErr
Indicates an error condition if any of the specified pointers is NULL.

ippStsSizeErr
Indicates an error condition if any field of the roiSize is less than 2.

CbYCr422ToYCbCr420_Interlace
Converts interlaced 4:2:2 CbYCr image to 4:2:0 YCbCr image.

Syntax
IppStatus ippiCbYCr422ToYCbCr420_Interlace_8u_C2P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
pSrc
Pointer to the source image ROI.

srcStep
Distance in bytes between starts of consecutive lines in the source image.

pDst
Array of pointers to the ROI in each plane for destination image.
**dstStep**

Array of distances in bytes between starts of consecutive lines in each plane for a three-plane destination image.

**roiSize**

Size of the source and destination ROI in pixels, its width must be multiple of 2, and height must be multiple of 4.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts interlaced 4:2:2CbYCr two-channel image pSrc to the 4:2:0YCbCr three-plane image pDst (see Table "Pixel-Order Image Formats" and Table "Planar Image Formats"). The source image has the following sequence of samples: Cb0, Y0, Cr0, Y1, Cb1, Y2, Cr1, Y3, Cb2, ... Three-plane destination image has the following order of pointers: Y-plane, Cb-plane, Cr-plane.

The conversion is performed in accordance with the following formulas:

Y1\text{dest} = Y1\text{src};

Cb0(Cr0)\text{dest} = (3*Cb0(Cr0)\text{src} + Cb2(Cr2)\text{src} + 2)/4;

Cb1(Cr1)\text{dest} = (Cb1(Cr1)\text{src} + 3*Cb3(Cr3)\text{src} + 2)/4;

**Return Values**

- ippStsNoErr: Indicates no error. Any other value indicates an error.
- ippStsNullPtrErr: Indicates an error condition if any of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error condition if roiSize.width is less than 2, or roiSize.height is less than 4.
- ippStsDoubleSize: Indicates a warning if roiSize.width is not multiple of 2, or roiSize.height is not multiple of 4.

**CbYCr422ToYCrCb420**

Converts 4:2:2 CbYCr image to 4:2:0 YCrCb image.

**Syntax**

IppStatus ippiCbYCr422ToYCrCb420_8u_C2P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

**Include Files**

ippcc.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
**pDst**

Array of pointers to the ROI in each plane of the destination image.

**dstStep**

Array of distances in bytes between starts of consecutive lines in the destination image planes.

**roiSize**

Size of the source and destination ROI in pixels, height and width should be multiple of 2.

### Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:2:2CbYCr two-channel image `pSrc` to the 4:2:0YCrCb three-plane image `pDst`. The source image has the following sequence of samples: Cb0, Y0, Cr0, Y1, Cb1, Y2, Cr1, Y3, Cb2, ... . The destination image has the following order of pointers: Y-plane, Cr-plane, Cb-plane (see Table "Pixel-Order Image Formats" and Table "Planar Image Formats").

### Return Values

- **ippStsNoErr**
  
  Indicates no error. Any other value indicates an error.

- **ippStsNullPtrErr**
  
  Indicates an error condition if any of the specified pointers is NULL.

- **ippStsSizeErr**
  
  Indicates an error condition if any field of the `roiSize` is less than 2.

---

**CbYCr422ToYCbCr411**

*Converts 4:2:2 CbYCr image to 4:1:1 YCbCr image.*

### Syntax

```c
IppStatus ippiCbYCr422ToYCbCr411_8u_C2P3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
```

### Include Files

- `ippcc.h`

### Domain Dependencies

- **Headers:** `ippcore.h`, `ippvm.h`, `ippi.h`, `ipps.h`
- **Libraries:** `ippcore.lib`, `ippvm.lib`, `ippi.lib`, `ipps.lib`

### Parameters

- **pSrc**
  
  Pointer to the source image ROI.

- **srcStep**
  
  Distance in bytes between starts of consecutive lines in the source image.

- **pDst**
  
  Array of pointers to the ROI in each plane of the destination image.

- **dstStep**
  
  Array of distances in bytes between starts of consecutive lines in the destination image planes.

- **roiSize**
  
  Size of the ROI in pixels, its width should be multiple of 4.
Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:2:2CbYCr two-channel image pSrc to the 4:1:1YCbCr three-plane image pDst. The source image has the following sequence of samples: Cb0, Y0, Cr0, Y1, Cb1, Y2, Cr1, Y3, Cb2, ... . The destination image has the following order of pointers: Y-plane, Cb-plane, Cr-plane (see Table "Pixel-Order Image Formats" and Table "Planar Image Formats").

Return Values
ippStsNoErr Indicates no error. Any other value indicates an error.
ippStsNullPtrErr Indicates an error condition if any of the specified pointers is NULL.
ippStsSizeErr Indicates an error condition if roiSize.width is less than 4.

YCbCr420
Converts 4:2:0 YCbCr image.

Syntax
IppStatusippiYCbCr420_8u_P3P2R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDstY, int dstYStep, Ipp8u* pDstCbCr, int dstCbCrStep, IppiSize roiSize);
IppStatusippiYCbCr420_8u_P2P3R(const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
pSrc Array of pointers to the ROI in each plane for a three-plane source image.
srcStep Array of distances in bytes between starts of consecutive lines in each plane for a three-plane source image.
pSrcY Pointer to the ROI in the luminance plane for a two-plane source image.
srcYStep Distance in bytes between starts of consecutive lines in the luminance plane of a source image.
pSrcCbCr Pointer to the ROI in the interleaved chrominance plane for a two-plane source image.
srcCbCrStep Distance in bytes between starts of consecutive lines in the interleaved chrominance plane of the source image.
pDst Array of pointers to the ROI in each plane for a three-plane destination image.
dstStep
Array of distances in bytes between starts of consecutive lines in each plane for a three-plane destination image.

pDstY
Pointer to the ROI in the luminance plane for a two-plane destination image.

dstYStep
Distance in bytes between starts of consecutive lines in the luminance plane of a destination image.

pDstCbCr
Pointer to the ROI in the interleaved chrominance plane for a two-plane destination image.

dstCbCrStep
Distance in bytes between starts of consecutive lines in the chrominance plane of a destination image.

roiSize
Size of the source and destination ROI in pixels, height and width should be multiple of 2.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:2:0 three-plane (see Table "Planar Image Formats") source image pSrc to the 4:2:0 two-plane image and vice versa. Two-plane image contains luminance samples Y0, Y1, Y2, .. in the first plane, and interleaved chrominance samples Cb0, Cr0, Cb1, Cr1,... in the second plane.

Return Values
ippStsNoErr
Indicates no error. Any other value indicates an error.

ippStsNullPtrErr
Indicates an error condition if any of the specified pointers is NULL.

ippStsSizeErr
Indicates an error condition if any field of the roiSize is less than 2.

YCbCr420ToYCbCr422
Converts YCbCr image from 4:2:0 sampling format to 4:2:2 format.

Syntax
IppStatus ippiYCbCr420ToYCbCr422_8u_P3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiYCbCr420ToYCbCr422_8u_P2P3R(const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiYCbCr420ToYCbCr422_8u_P2C2R(const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);

Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
### Parameters

- **pSrc**
  Array of pointers to the ROI in each plane for a three-plane source image.

- **srcStep**
  Array of distances in bytes between starts of consecutive lines in each plane for a three-plane source image.

- **pSrcY**
  Pointer to the ROI in the luminance plane for a two-plane source image.

- **srcYStep**
  Distance in bytes between starts of consecutive lines in the luminance plane of a source image.

- **pSrcCbCr**
  Pointer to the ROI in the interleaved chrominance plane for a two-plane source image.

- **srcCbCrStep**
  Distance in bytes between starts of consecutive lines in the interleaved chrominance plane of the source image.

- **pDst**
  Pointer to the ROI in the pixel-order destination image. Array of pointers to the ROI in each plane of the planar destination image.

- **dstStep**
  Distance in bytes between starts of consecutive lines in the destination image. Array of distance values for the destination image planes.

- **roiSize**
  Size of the ROI in pixels, height and width should be multiple of 2.

### Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:2:0 planar source image `pSrc` to the 4:2:2 image `pDst`. The source image can be two- or three-plane image (see Table "Planar Image Formats"). The first plane of the two-plane source image `pSrcY` contains luminance samples Y0, Y1, Y2, ..., the second plane `pSrcCbCr` contains interleaved chrominance samples Cb0, Cr0, Cb1, Cr1, .... . The destination image `pDst` can be three-plane or two-channel (see Table "Pixel-Order Image Formats" and Table "Planar Image Formats").

### Return Values

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error.

- **ippStsNullPtrErr**
  Indicates an error condition if any of the specified pointers is NULL.

- **ippStsSizeErr**
  Indicates an error condition if any field of the `roiSize` is less than 2.

---

### YCbCr420ToYCbCr422_Filter

Convert 4:2:0 image to 4:2:2 image with additional filtering.

**Syntax**

```c
IppStatus ippiYCbCr420ToYCbCr422_Filter_8u_P3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiYCbCr420ToYCbCr422_Filter_8u_P2P3R(const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
```
IppStatus ippiYCbCr420ToYCbCr422_Filter_8u_P2C2R(const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst, int dstStep, IppSize roiSize, int layout);

**Include Files**
ippcc.h

**Domain Dependencies**
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

**Parameters**

**pSrc**
Array of pointers to the ROI in each plane for a three-plane source image.

**srcStep**
Array of distances in bytes between starts of consecutive lines in each plane for a three-plane source image.

**pSrcY**
Pointer to the ROI in the luminance plane for a two-plane source image.

**srcYStep**
Distance in bytes between starts of consecutive lines in the luminance plane of a source image.

**pSrcCbCr**
Pointer to the ROI in the interleaved chrominance plane for a two-plane source image.

**srcCbCrStep**
Distance in bytes between starts of consecutive lines in the interleaved chrominance plane of the source image.

**pDst**
Pointer to the ROI in the pixel-order destination image. Array of pointers to the ROI in each plane of the planar destination image.

**dstStep**
Distance in bytes between starts of consecutive lines in the destination image. Array of distance values for the destination image planes.

**roiSize**
Size of the ROI in pixels.

**layout**
Slice layout. Possible values:

- IPP_UPPER
- IPP_CENTER
- IPP_LOWER
- IPP_LOWER && IPP_UPPER
- IPP_UPPER && IPP_CENTER

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the 4:2:0 planar source image \( pSrc \) to the 4:2:2 image \( pDst \) and performs additional filtering. The source image can be two- or three-plane image (see Table "Planar Image Formats"). The first plane of the two-plane source image \( pSrcY \) contains luminance samples \( Y_0, Y_1, Y_2, \ldots \), the second plane \( pSrcCbCr \) contains interleaved chrominance samples \( Cb_0, Cr_0, Cb_1, Cr_1, \ldots \). The destination image \( pDst \) can be three-plane or two-channel (see Table "Pixel-Order Image Formats" and Table "Planar Image Formats").

The function flavors \texttt{ippiYCbCr420ToYCbCr422\_Filter\_8u\_P3R} and \texttt{ippiYCbCr420ToYCbCr422\_Filter\_8u\_P2P3R} additionally perform the vertical upsampling using a Catmull-Rom interpolation (cubic convolution interpolation). In this case \texttt{roiSize.width} should be a multiple of 2, and \texttt{roiSize.height} should be a multiple of 8.

The function \texttt{ippiYCbCr420ToYCbCr422\_Filter\_8u\_P2C2R} additionally performs deinterlace filtering. Commonly it is used to process images that are divided into slices. In this case slice \texttt{layout} should be specified, since the function processes the first (upper), last (lowermost), and intermediate (middle) slices differently. The height of slices should be a multiple of 16.

Caution
The image slices should be processed exactly in the following order: the first slice, intermediate slices, the last slice.

The function may be applied to a not-sliced image as well. In this case \texttt{roiSize.width} and \texttt{roiSize.height} should be a multiple of 2.

Return Values

\begin{itemize}
\item \texttt{ippStsNoErr} Indicates no error. Any other value indicates an error.
\item \texttt{ippStsNullPtrErr} Indicates an error condition if any of the specified pointers is NULL.
\item \texttt{ippStsSizeErr} Indicates an error condition if \texttt{roiSize.width} has wrong value.
\end{itemize}

\begin{function}
\textbf{YCbcR420To422\_Interlace}
\begin{verbatim}
Converts interlaced YCbCr image from 4:2:0 sampling format to 4:2:2 format.
\end{verbatim}
\begin{syntax}
IppStatus ippiYCbCr420To422\_Interlace\_8u\_P3R(const Ipp8u* \( pSrc[3] \), int \texttt{srcStep[3]}, Ipp8u* \( pDst[3] \), int \texttt{dstStep[3]}, IppSize \texttt{roiSize});
\end{syntax}
\begin{includefiles}
ippcc.h
\end{includefiles}
\begin{domaindependencies}
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
\end{domaindependencies}
\begin{parameters}
\item \texttt{pSrc} Array of pointers to the ROI in each plane for source image.
\end{parameters}
\end{function}
**srcStep**
Array of distances in bytes between starts of consecutive lines in each plane for the source image.

**pDst**
Array of pointers to the ROI in each plane for destination image.

**dstStep**
Array of distances in bytes between starts of consecutive lines in each plane for the destination image.

**roiSize**
Size of the source and destination ROI in pixels, its width must be multiple of 2, and height must be multiple of 4.

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the interlaced planar 4:2:0 source image `pSrc` to the 4:2:2 image `pDst`. Three-plane image has the following order of pointers: Y-plane, Cb-plane, Cr-plane.

The conversion is performed in accordance with the following formulas:

\[
Y_{\text{dest}} = Y_{\text{src}}; \\
C_{b0(0)}_{\text{dest}} = (5\times C_{b0(0)}_{\text{src}} + 3\times C_{b2(2)}_{\text{src}} + 4)/8; \\
C_{b1(1)}_{\text{dest}} = (7\times C_{b1(1)}_{\text{src}} + C_{b3(3)}_{\text{src}} + 4)/8; \\
C_{b2(2)}_{\text{dest}} = (C_{b0(0)}_{\text{src}} + 7\times C_{b2(2)}_{\text{src}} + 4)/8; \\
C_{b3(3)}_{\text{dest}} = (3\times C_{b1(1)}_{\text{src}} + 5\times C_{b3(3)}_{\text{src}} + 4)/8; \\
\]

**Return Values**

ippStsNoErr Indicates no error. Any other value indicates an error.

ippStsNullPtrErr Indicates an error condition if any of the specified pointers is NULL.

ippStsSizeErr Indicates an error condition if `roiSize.width` is less than 2, or `roiSize.height` is less than 4.

ippStsDoubleSize Indicates a warning if `roiSize.width` is not multiple of 2, or `roiSize.height` is not multiple of 4.

**YCbCr420ToCbYCr422**
Converts 4:2:0 YCbCr image to 4:2:2 CbYCr image.

**Syntax**

```c
IppStatus ippiYCbCr420ToCbYCr422_8u_P2C2R(const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
```

**Include Files**

ippcc.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
**Parameters**

- **pSrcY**
  - Pointer to the ROI in the luminance plane of the source image.
- **srcYStep**
  - Distance in bytes between starts of consecutive lines in the luminance plane of the source image.
- **pSrcCbCr**
  - Pointer to the ROI in the interleaved chrominance plane of the source image.
- **srcCbCrStep**
  - Distance in bytes between starts of consecutive lines in the interleaved chrominance plane of the source image.
- **pDst**
  - Pointer to the destination image ROI.
- **dstStep**
  - Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**
  - Size of the source and destination ROI in pixels, height and width should be multiple of 2.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the planar 4:2:0 two-plane source image to the pixel-order 4:2:2 two-channel image. The first plane of the source image `pSrcY` contains luminance samples $Y_0, Y_1, Y_2, ...$, the second plane `pSrcCbCr` contains interleaved chrominance samples $Cb_0, Cr_0, Cb_1, Cr_1, ...$. The destination image `pDst` has the following sequence of samples: $Cb_0, Y_0, Cr_0, Y_1, Cb_1, Y_2, Cr_1, Y_3, Cb_2, ...$

**Return Values**

- **ippStsNoErr**
  - Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**
  - Indicates an error condition if any of the specified pointers is NULL.
- **ippStsSizeErr**
  - Indicates an error condition if any field of the `roiSize` is less than 2.

**YCbCr420ToCbYCr422_Interlace**

Converts interlaced 4:2:0 YCbCr image to 4:2:2 CbYCr image.

**Syntax**

```c
IppStatus ippiYCbCr420ToCbYCr422_Interlace_8u_P3C2R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);
```

**Include Files**

ippcc.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**
  - Array of pointers to the ROI in each plane for source image.
**srcStep**
Array of distances in bytes between starts of consecutive lines in each plane for the source image.

**pDst**
Pointer to the destination image ROI.

**dstStep**
Distance in bytes between starts of consecutive lines in the destination image.

**roiSize**
Size of the source and destination ROI in pixels, its width must be multiple of 2, and height must be multiple of 4.

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the interlaced planar 4:2:0 image to the pixel-order 4:2:2 two-channel image. Three-plane source image has the following order of pointers: Y-plane, Cb-plane, Cr-plane. The destination image pDst has the following sequence of samples: Cb0, Y0, Cr0, Y1, Cb1, Y2, Cr1, Y3, Cb2, ...

The conversion is performed in accordance with the following formulas:

\[
Y_{\text{dest}} = Y_{\text{src}}; \\
C_{b0(\text{Cr0})}_{\text{dest}} = (5* C_{b0(\text{Cr0})}_{\text{src}} + 3* C_{b2(\text{Cr2})}_{\text{src}} + 4)/8; \\
C_{b1(\text{Cr1})}_{\text{dest}} = (7* C_{b1(\text{Cr1})}_{\text{src}} + C_{b3(\text{Cr3})}_{\text{src}} + 4)/8; \\
C_{b2(\text{Cr2})}_{\text{dest}} = (C_{b0(\text{Cr0})}_{\text{src}} + 7* C_{b2(\text{Cr2})}_{\text{src}} + 4)/8; \\
C_{b3(\text{Cr3})}_{\text{dest}} = (3* C_{b1(\text{Cr1})}_{\text{src}} + 5* C_{b3(\text{Cr3})}_{\text{src}} + 4)/8; \\
\]

**Return Values**

- **ippStsNoErr** Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr** Indicates an error condition if any of the specified pointers is NULL.
- **ippStsSizeErr** Indicates an error condition if roiSize.width is less than 2, or roiSize.height is less than 4.
- **ippStsDoubleSize** Indicates a warning if roiSize.width is not multiple of 2, or roiSize.height is not multiple of 4.

**YCbCr420ToYCrCb420**

*Converts 4:2:0 YCbCr image to 4:2:0 YCrCb image.*

**Syntax**

```
IppStatus ippiYCbCr420ToYCrCb420_8u_P2P3R(const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
```

**Include Files**

ippcc.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipp.h, ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipp.lib, ippi.lib
Parameters

pSrcY
Pointer to the ROI in the luminance plane of the source image.

srcYStep
Distance in bytes between starts of consecutive lines in the luminance plane of the source image.

pSrcCbCr
Pointer to the ROI in the interleaved chrominance plane of the source image.

srcCbCrStep
Distance in bytes between starts of consecutive lines in the interleaved chrominance plane of the source image.

pDst
Array of pointers to the ROI in each plane of the destination image.

dstStep
Array of distances in bytes between starts of consecutive lines in the destination image planes.

roiSize
Size of the source and destination ROI in pixels, height and width should be multiple of 2.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:2:0 two-plane source image pSrc to the 4:2:0 three-plane image pDst. The first plane of the source image pSrcY contains luminance samples Y0, Y1, Y2, ..., the second plane pSrcCbCr contains interleaved chrominance samples Cb0, Cr0, Cb1, Cr1, .... The destination image pDst has the following order of pointers: Y-plane, Cr-plane, Cb-plane (see Table "Planar Image Formats").

Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error.

ippStsNullPtrErr
Indicates an error condition if any of the specified pointers is NULL.

ippStsSizeErr
Indicates an error condition if any field of the roiSize is less than 2.

YCbCr420ToYCrCb420_Filter

Convert 4:2:0 YCbCr image to 4:2:0 YCrCb image with deinterlace filtering.

Syntax

IppStatusippiYCbCr420ToYCrCb420_Filter_8u_P2P3R(const Ipp8u* pSrcY, int srcYStep,
const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst[3], int dstStep[3], IippiSize roiSize, int layout);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Parameters

- **pSrcY**: Pointer to the ROI in the luminance plane of the source image.
- **srcYStep**: Distance in bytes between starts of consecutive lines in the luminance plane of the source image.
- **pSrcCbCr**: Pointer to the ROI in the interleaved chrominance plane of the source image.
- **srcCbCrStep**: Distance in bytes between starts of consecutive lines in the interleaved chrominance plane of the source image.
- **pDst**: Array of pointers to the ROI in each plane of the destination image.
- **dstStep**: Array of distances in bytes between starts of consecutive lines in the destination image planes.
- **roiSize**: Size of the source and destination ROI in pixels, height and width should be multiple of 2.
- **layout**: Slice layout. Possible values:
  - IPP_UPPER: Upper (first) slice
  - IPP_CENTER: Middle slices
  - IPP_LOWER: Lowermost (last) slice
  - IPP_LOWER && IPP_UPPER && IPP_CENTER: Image is not sliced

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:2:0 two-plane source image to the 4:2:0 three-plane image. The first plane of the source image **pSrcY** contains luminance samples Y0, Y1, Y2, ..., the second plane **pSrcCbCr** contains interleaved chrominance samples Cb0, Cr0, Cb1, Crl, .... The destination image **pDst** has the following order of pointers: Y-plane, Cr-plane, Cb-plane. The function additionally performs deinterlace filtering.

Commonly it is used to process sliced images. In this case the slice **layout** should be specified, since the function processes the first (upper), last (lowermost), and intermediate (middle) slices differently. The height of slices should be a multiple of 16. The function may be applied to a not-sliced image as well.

**Caution**

The image slices should be processed exactly in the following order: the first slice, intermediate slices, the last slice.

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**: Indicates an error condition if any of the specified pointers is NULL.
Indicates an error condition if any field of the \texttt{roiSize} is less than 2.

\textbf{YCbCr420ToYCbCr411}

\textit{Converts YCbCr image from 4:2:0 sampling format to 4:1:1 format.}

\textbf{Syntax}

\begin{verbatim}
IppStatus ippiYCbCr420ToYCbCr411_8u_P3P2R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDstY, int dstYStep, Ipp8u* pDstCbCr, int dstCbCrStep, IppiSize roiSize);
IppStatus ippiYCbCr420ToYCbCr411_8u_P2P3R(const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiYCbCr420To411_8u_P3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiYCbCr1620To420_8u_P3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiYCbCr1620To420_8u_P3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
\end{verbatim}

\textbf{Include Files}

ippcc.h

\textbf{Domain Dependencies}

\textbf{Headers:} ippcore.h, ippvm.h, ipps.h, ippi.h

\textbf{Libraries:} ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

\textbf{Parameters}

\begin{itemize}
  \item \texttt{pSrc} \hspace{2cm} Array of pointers to the ROI in each plane for a three-plane source image.
  \item \texttt{srcStep} \hspace{2cm} Array of distances in bytes between starts of consecutive lines in each plane for a three-plane source image.
  \item \texttt{pSrcY} \hspace{2cm} Pointer to the ROI in the luminance plane for a two-plane source image.
  \item \texttt{srcYStep} \hspace{2cm} Distance in bytes between starts of consecutive lines in the luminance plane of a source image.
  \item \texttt{pSrcCbCr} \hspace{2cm} Pointer to the ROI in the interleaved chrominance plane for a two-plane source image.
  \item \texttt{srcCbCrStep} \hspace{2cm} Distance in bytes between starts of consecutive lines in the interleaved chrominance plane of the source image.
  \item \texttt{pDst} \hspace{2cm} Array of pointers to the ROI in each plane for a three-plane destination image.
  \item \texttt{dstStep} \hspace{2cm} Array of distances in bytes between starts of consecutive lines in each plane for a three-plane destination image.
  \item \texttt{pDstY} \hspace{2cm} Pointer to the ROI in the luminance plane for a two-plane destination image.
\end{itemize}
dstYStep

Distance in bytes between starts of consecutive lines in the luminance plane of a destination image.

pDstCbCr

Pointer to the ROI in the interleaved chrominance plane for a two-plane destination image.

dstCbCrStep

Distance in bytes between starts of consecutive lines in the chrominance plane of a destination image.

roiSize

Size of the ROI in pixels, its width should be multiple of 4, its height should be multiple of 2.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:2:0 source image to the 4:1:1 destination image. The source two-plane image is converted to destination three-plane image and vice versa. The first plane of the two-plane image contains luminance samples Y0, Y1, Y2, ..., the second plane contains interleaved chrominance samples Cb0, Cr0, Cb1, Cr1, .... The three-plane image has the following order of pointers: Y-plane, Cb-plane, Cr-plane (see Table "Planar Image Formats").

**Return Values**

ippStsNoErr

Indicates no error. Any other value indicates an error.

ippStsNullPtrErr

Indicates an error condition if any of the specified pointers is NULL.

ippStsSizeErr

Indicates an error condition if roiSize.width is less than 4 or roiSize.height is less than 2.

**YCrCb420ToYCbCr422**

Converts 4:2:0 YCrCb image to 4:2:2 YCbCr image.

**Syntax**

IppStatus ippiYCrCb420ToYCbCr422_8u_P3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

IppStatus ippiYCrCb420ToYCbCr422_8u_P3C2R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);

**Include Files**

ippcc.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

pSrc

Array of pointers to the ROI in each plane of the source image.

srcStep

Array of distances in bytes between starts of consecutive lines in each plane of the source image.
**YCrCb420ToYCbCr422_Filter**

Converts 4:2:0 YCrCb image to 4:2:2 YCbCr image with additional filtering.

**Syntax**

IppStatus ippiYCrCb420ToYCbCr422_Filter_8u_P3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

**Include Files**

ippcc.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

**Parameters**

- **pSrc**: Array of pointers to the ROI in each plane of the source image.
- **srcStep**: Array of distances in bytes between starts of consecutive lines in each plane of the source image.
- **pDst**: Array of pointers to the ROI in each plane of the destination image.
- **dstStep**: Array of distances in bytes between starts of consecutive lines in each plane of the destination image.
- **roiSize**: Size of the ROI in pixels, its width should be multiple of 2, its height should be multiple of 8.
Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the $4:2:0$YCrCb three-plane image $pSrc$ to the $4:2:2$YCbCr three-plane image $pDst$ (see Table "Planar Image Formats"). Additionally, this function performs the vertical upsampling using a Catmull-Rom interpolation (cubic convolution interpolation).

Return Values
- ippStsNoErr: Indicates no error. Any other value indicates an error.
- ippStsNullPtrErr: Indicates an error condition if any of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error condition if $roiSize.width$ is less than 2 or $roiSize.height$ is less than 8.

YCrCb420ToCbYCr422
Converts $4:2:0$ YCrCb image to $4:2:2$ CbYCr image.

Syntax
```c
IppStatus ippiYCrCb420ToCbYCr422_8u_P3C2R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);
```

Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
- $pSrc$: Array of pointers to the ROI in each plane of the source image.
- $srcStep$: Array of distances in bytes between starts of consecutive lines in each plane of the source image.
- $pDst$: Pointer to the destination image ROI.
- $dstStep$: Distance in bytes between starts of consecutive lines in the destination image.
- $roiSize$: Size of the source and destination ROI in pixels, height and width should be multiple of 2.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the $4:2:0$YCrCb three-plane image $pSrc$ (see Table "Planar Image Formats") to the $4:2:2$CbYCr two-channel image $pDst$ with the following sequence of samples: Cb0, Y0, Cr0, Y1, Cb1, Y2, Cr1, Y3, Cb2, ... (see Table "Pixel-Order Image Formats").
Return Values

ippStsNoErr  
Indicates no error. Any other value indicates an error.

ippStsNullPtrErr  
Indicates an error condition if any of the specified pointers is NULL.

ippStsSizeErr  
Indicates an error condition if any field of the roiSize is less than 2.

**YCrCb420ToYCbCr420**

*Converts 4:2:0 YCrCb image to 4:2:0 YCbCr image.*

**Syntax**

IppStatus ippiYCrCb420ToYCbCr420_8u_P3P2R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDstY, int dstYStep, Ipp8u* pDstCbCr, int dstCbCrStep, IppiSize roiSize);

**Include Files**

ippcc.h

**Domain Dependencies**

*Headers:* ippcore.h, ippvm.h, ipps.h, ippi.h

*Libraries:* ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

**Parameters**

- **pSrc**
  Array of pointers to the ROI in each plane of the source image.

- **srcStep**
  Array of distances in bytes between starts of consecutive lines in each plane of the source image.

- **pDstY**
  Pointer to the ROI in the luminance plane of a destination image.

- **dstYStep**
  Distance in bytes between starts of consecutive lines in the luminance plane of the destination image.

- **pDstCbCr**
  Pointer to the ROI in the interleaved chrominance plane of the destination image.

- **dstCbCrStep**
  Distance in bytes between starts of consecutive lines in the interleaved chrominance plane of a destination image.

- **roiSize**
  Size of the source and destination ROI in pixels, height and width should be multiple of 2.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:2:0 YCrCb three-plane image *pSrc* (see Table “Planar Image Formats”) to the 4:2:0 YCbCr two-plane image that contains luminance samples *Y0, Y1, Y2*, .. in the first plane *pDstY*, and interleaved chrominance samples *Cb0, Cr0, Cb1, Cr1, ...* in the second plane *pDstCbCr*.

**Return Values**

ippStsNoErr  
Indicates no error. Any other value indicates an error.
Indicates an error condition if any of the specified pointers is NULL.

Indicates an error condition if any field of the roiSize is less than 2.

**YCrCb420ToYCbCr411**

*Converts 4:2:0 YCrCb image to 4:1:1 YCbCr image.*

**Syntax**

```c
IppStatus ippiYCrCb420ToYCbCr411_8u_P3P2R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDstY, int dstYStep, Ipp8u* pDstCbCr, int dstCbCrStep, IppiSize roiSize);
```

**Include Files**

ippcc.h

**Domain Dependencies**

*Headers:* ippcore.h, ippvm.h, ipps.h,ippi.h

*Libraries:* ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- `pSrc` - Array of pointers to the ROI in each plane of the source image.
- `srcStep` - Array of distances in bytes between starts of consecutive lines in each plane of the source image.
- `pDstY` - Pointer to the ROI in the luminance plane of a destination image.
- `dstYStep` - Distance in bytes between starts of consecutive lines in the luminance plane of the destination image.
- `pDstCbCr` - Pointer to the ROI in the interleaved chrominance plane of the destination image.
- `dstCbCrStep` - Distance in bytes between starts of consecutive lines in the interleaved chrominance plane of a destination image.
- `roiSize` - Size of the ROI in pixels, its width should be multiple of 4, its height should be multiple of 2.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:2:0 YCrCb three-plane image `pSrc` (see Table “Planar Image Formats”) to the 4:1:1 YCbCr two-plane image that contains luminance samples Y0, Y1, Y2, .. in the first plane `pDstY`, and interleaved chrominance samples Cb0, Cr0, Cb1, Cr1, ... in the second plane `pDstCbCr`..

**Return Values**

- `ippStsNoErr` - Indicates no error. Any other value indicates an error.
- `ippStsNullPtrErr` - Indicates an error condition if any of the specified pointers is NULL.
- `ippStsSizeErr` - Indicates an error condition if `roiSize.width` is less than 4 or `roiSize.height` is less than 2.
**YCbCr411**

*Converts 4:1:1 YCbCr image.*

**Syntax**

IppStatus ippiYCbCr411_8u_P3P2R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDstY, int dstYStep, Ipp8u* pDstCbCr, int dstCbCrStep, IppiSize roiSize);

IppStatus ippiYCbCr411_8u_P2P3R(const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);

**Include Files**

ippcc.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**
  Array of pointers to the ROI in each plane for a three-plane source image.

- **srcStep**
  Array of distances in bytes between starts of consecutive lines in each plane for a three-plane source image.

- **pSrcY**
  Pointer to the ROI in the luminance plane for a two-plane source image.

- **srcYStep**
  Distance in bytes between starts of consecutive lines in the luminance plane of a source image.

- **pSrcCbCr**
  Pointer to the ROI in the interleaved chrominance plane for a two-plane source image.

- **srcCbCrStep**
  Distance in bytes between starts of consecutive lines in the interleaved chrominance plane of the source image.

- **pDst**
  Array of pointers to the ROI in each plane for a three-plane destination image.

- **dstStep**
  Array of distances in bytes between starts of consecutive lines in each plane for a three-plane destination image.

- **pDstY**
  Pointer to the ROI in the luminance plane for a two-plane destination image.

- **dstYStep**
  Distance in bytes between starts of consecutive lines in the luminance plane of a destination image.

- **pDstCbCr**
  Pointer to the ROI in the interleaved chrominance plane for a two-plane destination image.

- **dstCbCrStep**
  Distance in bytes between starts of consecutive lines in the chrominance plane of a destination image.

- **roiSize**
  Size of the ROI in pixels, its width should be multiple of 4.

**Description**

This function operates with ROI (see *Regions of Interest in Intel IPP*).
This function converts the 4:1:1 three-plane (see Table "Planar Image Formats") source image \( p_{Src} \) to the 4:1:1 two-plane image and vice versa. Two-plane image contains luminance samples \( Y_0, Y_1, Y_2, \ldots \) in the first plane, and interleaved chrominance samples \( Cb_0, Cr_0, Cb_1, Cr_1, \ldots \) in the second plane.

**Return Values**

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error condition if any of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error condition if ( roiSize.width ) is less than 4.</td>
</tr>
</tbody>
</table>

**YCbCr411ToYCbCr422**

*Converts 4:1:1 YCbCr image to 4:2:2 YCbCr image.*

**Syntax**

```c
IppStatus ippiYCbCr411ToYCbCr422_8u_P3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiYCbCr411ToYCbCr422_8u_P3C2R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiYCbCr411ToYCbCr422_8u_P2P3R(const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiYCbCr411ToYCbCr422_8u_P2C2R(const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
```

**Include Files**

ippcc.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

**Parameters**

- \( p_{Src} \)
  - Array of pointers to the ROI in each plane for a three-plane source image.
- \( src_{Step} \)
  - Array of distances in bytes between starts of consecutive lines in each plane for a three-plane source image.
- \( p_{SrcY} \)
  - Pointer to the ROI in the luminance plane for a two-plane source image.
- \( src_{YStep} \)
  - Distance in bytes between starts of consecutive lines in the luminance plane of a source image.
- \( p_{SrcCbCr} \)
  - Pointer to the ROI in the interleaved chrominance plane for a two-plane source image.
- \( src_{CbCrStep} \)
  - Distance in bytes between starts of consecutive lines in the interleaved chrominance plane of the source image.
- \( p_{Dst} \)
  - Pointer to the ROI in the pixel-order destination image. Array of pointers to the ROI in each plane of the planar destination image.
**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts 4:1:1 planar source image `pSrc` to the 4:2:2 image `pDst`. The first plane of the two-plane source image `pSrcY` contains luminance samples `Y0, Y1, Y2,...`, the second plane `pSrcCbCr` contains interleaved chrominance samples `Cb0, Cr0, Cb1, Cr1,...`. The destination image `pDst` can be either three-plane (see Table "Planar Image Formats") or two-channel image (see Table "Pixel-Order Image Formats").

**Return Values**

- `ippStsNoErr`: Indicates no error. Any other value indicates an error.
- `ippStsNullPtrErr`: Indicates an error condition if any of the specified pointers is NULL.
- `ippStsSizeErr`: Indicates an error condition if `roiSize.width` is less than 4.

---

**YCbCr411ToYCrCb422**

*Converts 4:1:1 YCbCr image to 4:2:2 YCrCb image.*

**Syntax**

```c
IppStatus ippiYCbCr411ToYCrCb422_8u_P3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiYCbCr411ToYCrCb422_8u_P3C2R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst, int dstStep, IppiSize roiSize);
```

**Include Files**

`ippcc.h`

**Domain Dependencies**

- Headers: `ippicore.h`, `ippvm.h`, `ipps.h`, `ippi.h`
- Libraries: `ippicore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`

**Parameters**

- `pSrc`: Array of pointers to the ROI in each plane for a three-plane source image.
- `srcStep`: Array of distances in bytes between starts of consecutive lines in each plane for a three-plane source image.
- `pDst`: Pointer to the ROI in the pixel-order destination image. Array of pointers to the ROI in each plane of the planar destination image.
- `pDst`: Pointer to the ROI in the pixel-order destination image. Array of pointers to the ROI in each plane of the planar destination image.
- `dstStep`: Distance in bytes between starts of consecutive lines in the destination image. Array of distance values for the destination image planes.
Size of the ROI in pixels, its width should be multiple of 4.

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the 4:1:1 three-plane image `pSrc` to the 4:2:2 two-channel or three-plane image `pDst` with different order of components. The source image has the following order of pointers: Y-plane, Cb-plane, Cr-plane (see Table "Planar Image Formats"). The three-plane destination image has the following order of pointers: Y-plane, Cr-plane, Cb-plane (see Table "Planar Image Formats"), and two-channel destination image has the following sequence of samples: Y0, Cr0, Y1, Cb0, Y2, Cr1, Y3, Cb1, ... (see Table "Pixel-Order Image Formats").

**Return Values**
- `ippStsNoErr` Indicates no error. Any other value indicates an error.
- `ippStsNullPtrErr` Indicates an error condition if any of the specified pointers is NULL.
- `ippStsSizeErr` Indicates an error condition if `roiSize.width` is less than 4.

**YCbCr411ToYCbCr420, YCbCr411To420**
*Converts 4:1:1 YCbCr image to 4:2:0 YCbCr image.*

**Syntax**
```c
IppStatus ippiYCbCr411ToYCbCr420_8u_P3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiYCbCr411ToYCbCr420_8u_P3P2R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDstY, int dstYStep, Ipp8u* pDstCbCr, int dstCbCrStep, IppiSize roiSize);
IppStatus ippiYCbCr411ToYCbCr420_8u_P2P3R(const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
IppStatus ippiYCbCr411To420_8u_P3R(const Ipp8u* pSrc[3], int srcStep[3], Ipp8u* pDst[3], int dstStep[3], IppiSize roiSize);
```

**Include Files**
ipcc.h

**Domain Dependencies**
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**
- `pSrc` Array of pointers to the ROI in each plane for a three-plane source image.
- `srcStep` Array of distances in bytes between starts of consecutive lines in each plane for a three-plane source image.
- `pSrcY` Pointer to the ROI in the luminance plane for a two-plane source image.
**srcYStep**
Distance in bytes between starts of consecutive lines in the luminance plane of a source image.

**pSrcCbCr**
Pointer to the ROI in the interleaved chrominance plane for a two-plane source image.

**srcCbCrStep**
Distance in bytes between starts of consecutive lines in the interleaved chrominance plane of the source image.

**pDst**
Array of pointers to the ROI in each plane for a three-plane destination image.

**dstStep**
Array of distances in bytes between starts of consecutive lines in each plane for a three-plane destination image.

**pDstY**
Pointer to the ROI in the luminance plane for a two-plane destination image.

**dstYStep**
Distance in bytes between starts of consecutive lines in the luminance plane of a destination image.

**pDstCbCr**
Pointer to the ROI in the interleaved chrominance plane for a two-plane destination image.

**dstCbCrStep**
Distance in bytes between starts of consecutive lines in the chrominance plane of a destination image.

**roiSize**
Size of the ROI in pixels, its width should be multiple of 4, its height should be multiple of 2.

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the 4:1:1 planar source image `pSrc` (see Table “Planar Image Formats”) to the 4:2:0 planar image `pDst`. Both source and destination images can be three- or two-plane. Three-plane images has the following order of pointers: Y-plane, Cb-plane, Cr-plane (see Table “Planar Image Formats”). Two-plane images contain luminance samples Y0, Y1, Y2, .. in the first plane, and interleaved chrominance samples Cb0, Cr0, Cb1, Cr1, ... in the second plane.

**Return Values**
- **ippStsNoErr**
  Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**
  Indicates an error condition if any of the specified pointers is NULL.
- **ippStsSizeErr**
  Indicates an error condition if roiSize.width is less than 4 or roiSize.height is less than 2.

---

**YCbCr411ToYCrCb420**
Converts 4:1:1 YCbCr image to 4:2:0 YCrCb image.

**Syntax**
```c
IppStatus ippiYCbCr411ToYCrCb420_8u_P2P3R(const Ipp8u* pSrcY, int srcYStep, const Ipp8u* pSrcCbCr, int srcCbCrStep, Ipp8u* pDst[3], int dstStep[3], IppSize roiSize);
```

**Include Files**
ippcc.h
Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters

- **pSrcY**: Pointer to the ROI in the luminance plane of the source image.
- **srcYStep**: Distance in bytes between starts of consecutive lines in the luminance plane of the source image.
- **pSrcCbCr**: Pointer to the ROI in the interleaved chrominance plane of the source image.
- **srcCbCrStep**: Distance in bytes between starts of consecutive lines in the interleaved chrominance plane of the source image.
- **pDst**: Array of pointers to the ROI in each plane of the destination image.
- **dstStep**: Array of distances in bytes between starts of consecutive lines in each plane of the destination image.
- **roiSize**: Size of the ROI in pixels, its width should be multiple of 4, its height should be multiple of 2.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the 4:1:1 two-plane source image `pSrc` to the 4:2:0 three-plane image `pDst` with a different order of components. The first plane of the source image `pSrcY` contains luminance samples Y0, Y1, Y2, ..., the second plane `pSrcCbCr` contains interleaved chrominance samples Cb0, Cr0, Cb1, Cr1, ... .The destination image has the following order of pointers: Y-plane, Cr-plane, Cb-plane (see Table "Planar Image Formats"),

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**: Indicates an error condition if any of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if `roiSize.width` is less than 4 or `roiSize.height` is less than 2.

Color Twist
Color twist conversion functions use values of all color channels of a source pixel to compute the resultant destination channel value. The destination channel value is obtained as the result of multiplying the corresponding row of the color-twist matrix by the vector of source pixel channel values.

For example, if (r, g, b) is a source pixel, then the destination pixel values (R, G, B) are computed as follows:

- R = t_{11} * r + t_{12} * g + t_{13} * b + t_{14}
- G = t_{21} * r + t_{22} * g + t_{23} * b + t_{24}
- B = t_{31} * r + t_{32} * g + t_{33} * b + t_{34}

where
is the color twist matrix. The color twist matrix used by the Intel IPP functions is a matrix of size 3x4, or 4x4 with floating-point elements. The matrix elements are specific for each particular type of color conversion.

**ColorTwist**

*Applies a color twist matrix to an image with floating-point pixel values.*

**Syntax**

**Case 1: Not-in-place operation on pixel-order data**

```c
IppStatus ippiColorTwist_<mod>(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, const Ipp32f twist[3][4]);
```

Supported values for `mod`:

- `32f_C3R`
- `32f_AC4R`

```c
IppStatus ippiColorTwist_32f_C4R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, const Ipp32f twist[4][4]);
```

**Case 2: Not-in-place operation on planar data**

```c
IppStatus ippiColorTwist_32f_P3R(const Ipp32f* pSrc[3], int srcStep, Ipp32f* pDst[3], int dstStep, IppiSize roiSize, const Ipp32f twist[3][4]);
```

**Case 3: In-place operation on pixel-order data**

```c
IppStatus ippiColorTwist_<mod>(Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize, const Ipp32f twist[3][4]);
```

Supported values for `mod`:

- `32f_C3IR`
- `32f_AC4IR`

**Case 4: In-place operation on planar data**

```c
IppStatus ippiColorTwist_32f_IP3R(Ipp32f* pSrcDst[3], int srcDstStep, IppiSize roiSize, const Ipp32f twist[3][4]);
```

**Include Files**

ippcc.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- `pSrc` Pointer to the source image ROI.
**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function applies the color-twist matrix to all three color channels in the source image with floating-point pixel values to obtain the resulting data in the destination image. The destination channel value is obtained as the result of multiplying the corresponding row of the color-twist matrix by the vector of source pixel channel values.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**: Indicates an error condition if pSrc, pDst, or pSrcDst is NULL.
- **ippiSizeErr**: Indicates an error condition if roiSize has a field with a zero or negative value.

**ColorTwist32f**

Applies a color twist matrix to an image with integer pixel values.

**Syntax**

**Case 1: Not-in-place operation on pixel-order data**

```c
IppStatus ippiColorTwist32f_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp32f twist[3][4]);
```

Supported values for `mod`:

- 8u_C3R
- 16u_C3R
- 16s_C3R
- 8u_AC4R
- 16u_AC4R
- 16s_AC4R

**Case 2: Not-in-place operation on planar data**

```c
IppStatus ippiColorTwist32f_<mod>(const Ipp<datatype>* pSrc[3], int srcStep, Ipp<datatype>* pDst[3], int dstStep, IppiSize roiSize, const Ipp32f twist[3][4]);
```

Supported values for `mod`:

- 8u_P3R
- 16u_P3R
- 16s_P3R
Case 3: In-place operation on pixel-order data

IppStatus ippiColorTwist32f_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, const Ipp32f twist[3][4]);

Supported values for mod:
- 8u_C3IR
- 16u_C3IR
- 16s_C3IR
- 8u_AC4IR
- 16u_AC4IR
- 16s_AC4IR

Case 4: In-place operation on planar data

IppStatus ippiColorTwist32f_<mod>(Ipp<datatype>* pSrcDst[3], int srcDstStep, IppiSize roiSize, const Ipp32f twist[3][4]);

Supported values for mod:
- 8u_IP3R
- 16u_IP3R
- 16s_IP3R

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- pSrc
  Pointer to the source image ROI.
- srcStep
  Distance, in bytes, between the starting points of consecutive lines in the source image.
- pDst
  Pointer to the destination image ROI.
- dstStep
  Distance, in bytes, between the starting points of consecutive lines in the destination image.
- pSrcDst
  Pointer to the source and destination image ROI for the in-place operation.
- srcDstStep
  Distance, in bytes, between the starting points of consecutive lines in the source and destination image for the in-place operation.
- roiSize
  Size of the source and destination ROI in pixels.
- twist
  The array containing color-twist matrix elements.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function applies the color-twist matrix to all three color channel values in the integer source image to obtain the resulting data in the destination image. For example, the conversion from the RGB to the YCbCr format can be done as:

\[
Y = 0.299*R + 0.587*G + 0.114*B \\
Cb = -0.16874*R - 0.33126*G + 0.5*B + 0.5 \\
Cr = 0.5*R - 0.41869*G - 0.08131*B + 0.5
\]
which can be described in terms of the following color twist matrix:

```
0.29900f  0.58700f  0.11400f  0.000f
-0.16874f -0.33126f  0.50000f  128.0f
0.50000f -0.41869f -0.08131f  128.0f
```

Color-twist matrices may also be used to perform many other color conversions.

### Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**: Indicates an error condition if `pSrc`, `pDst`, or `pSrcDst` is `NULL`.
- **ippStsSizeErr**: Indicates an error condition if `roiSize` has a field with a zero or negative value.

### Color Keying

#### CompColorKey

*Perform color keying of two images.*

**Syntax**

**Case 1: Operation on one-channel data**

```
IppStatus ippiCompColorKey_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, Ipp<datatype> colorKey);
```

**Supported values for mod:**

- 8u_C1R
- 16u_C1R
- 16s_C1R

**Case 2: Operation on multi-channel data**

```
IppStatus ippiCompColorKey_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, Ipp<datatype> colorKey[3]);
```

**Supported values for mod:**

- 8u_C3R
- 16u_C3R
- 16s_C3R

```
IppStatus ippiCompColorKey_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, Ipp<datatype> colorKey[4]);
```

**Supported values for mod:**

- 8u_C4R
- 16u_C4R
- 16s_C4R

### Include Files

`ippi.h`

### Domain Dependencies

*Headers:* `ippcore.h`, `ippvm.h`, `ipps.h`
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc1, pSrc2**: Pointer to the source images ROI.
- **src1Step, src2Step**: Distances in bytes between starts of consecutive lines in the source images.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**: Size of the source and destination ROI in pixels.
- **colorKey**: Value of the key color for 1-channel images, array of color values for multi-channel images.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function replaces all areas of the source image `pSrc1` containing the specified key color `colorKey` with the corresponding pixels of the background image `pSrc2` and stores the result in the destination image `pDst`.

The Figure Applying the Function ippiCompColorKey to Sample Images shows an example of how the function `ippiCompColorKey` works.

Applying the Function ippiCompColorKey to Sample Images

![Sample Images](image)

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if `roiSize` has a field with a zero or negative value.
- **ippStsStepErr**: Indicates an error condition if one of the step values is less than or equal to 0.

**AlphaCompColorKey**

Performs color keying and alpha composition of two images.
Syntax

IppStatus ippiAlphaCompColorKey_8u_AC4R(const Ipp8u* pSrc1, int src1Step, Ipp8u alpha1, const Ipp8u* pSrc2, int src2Step, Ipp8u alpha2, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp8u colorKey[4], IppiAlphaType alphaType);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- 
  pSrc1, pSrc2: Pointer to the source images ROI.

- 
  src1Step, src2Step: Distances in bytes between starts of consecutive lines in the source images.

- 
  alpha1, alpha2: Alpha value.

- 
  pDst: Pointer to the destination image ROI.

- 
  dstStep: Distance in bytes between starts of consecutive lines in the destination image.

- 
  roiSize: Size of the source and destination ROI in pixels.

- 
  colorKey: Array of color values.

- 
  alphaType: The type of composition to perform (without pre-multiplying). See Table “Possible Values of alphaType Parameter” for more details.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function replaces all areas of the source image pSrc1 containing the specified key color colorKey with the corresponding pixels of the background image pSrc2 and additionally performs alpha composition (see supported Table “Types of Image Compositing Operations”) in accordance with the parameter alphaType. Note the alpha channel in the pDst is not changed after color keying.

The parameter alphaType should not be set to the values intended for operations with pre-multiplying.

Return Values

- 
  ippStsNoErr: Indicates no error. Any other value indicates an error.

- 
  ippStsNullPtrErr: Indicates an error condition if one of the specified pointers is NULL.

- 
  ippStsSizeErr: Indicates an error condition if roiSize has a field with a zero or negative value.

- 
  ippStsStepErr: Indicates an error condition if one of the step values is less than or equal to 0.

- 
  ippStsAlphaTypeErr: Indicates an error condition if alphaType specifies the unsupported type of composition.
**Gamma Correction**

**GammaFwd**  
Performs gamma-correction of the source image with RGB data.

**Syntax**

**Case 1: Not-in-place operation on integer pixel-order data**  
IppStatus ippiGammaFwd_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for `mod`:  
8u_C3R  16u_C3R  
8u_AC4R  16u_AC4R

**Case 2: Not-in-place operation on integer planar data**  
IppStatus ippiGammaFwd_<mod>(const Ipp<datatype>* pSrc[3], int srcStep, Ipp<datatype>* pDst[3], int dstStep, IppiSize roiSize);

Supported values for `mod`:  
8u_P3R  16u_P3R

**Case 3: Not-in-place operation on floating-point pixel-order data**  
IppStatus ippiGammaFwd_<mod>(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, Ipp32f vMin, Ipp32f vMax);

Supported values for `mod`:  
32f_C3R  32f_AC4R

**Case 4: Not-in-place operation on floating-point planar data**  
IppStatus ippiGammaFwd_<mod>(const Ipp32f* pSrc[3], int srcStep, Ipp32f* pDst[3], int dstStep, IppiSize roiSize, Ipp32f vMin, Ipp32f vMax);

**Case 5: In-place operation on integer pixel-order data**  
IppStatus ippiGammaFwd_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for `mod`:  
8u_C3IR  16u_C3IR  
8u_AC4IR  16u_AC4IR

**Case 6: In-place operation on integer planar data**  
IppStatus ippiGammaFwd_<mod>(Ipp<datatype>* pSrc[3], int srcDstStep, IppiSize roiSize);

Supported values for `mod`:  
8u_IP3R  16u_IP3R
Case 7: In-place operation on floating-point pixel-order data

IppStatus ippiGammaFwd_<mod>(Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp32f vMin, Ipp32f vMax);

Supported values for mod:

32f_C3IR
32f_AC4IR

Case 8: In-place operation on floating-point planar data

IppStatus ippiGammaFwd_32f_IP3R(Ipp32f* pSrcDst[3], int srcDstStep, IppiSize roiSize, Ipp32f vMin, Ipp32f vMax);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc Pointer to the ROI in the pixel-order source image. Array of pointers to the ROI in each plane of the planar source image.
srcStep Distance in bytes between starts of consecutive lines in the source image.
pDst Pointer to the ROI in the pixel-order destination image. Array of pointers to the ROI in each plane of the planar destination image.
dstStep Distance in bytes between starts of consecutive lines in the destination image.
pSrcDst Pointer to the source and destination image ROI for the in-place operation.
srcDstStep Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.
roiSize Size of the source and destination ROI in pixels.
vMin, vMax Minimum and maximum values of the input floating-point data.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function performs gamma-correction of the source image with RGB data. It uses the following basic equations to convert an RGB image to the gamma-corrected R'G'B' image:

for R,G,B < 0.018
R' = 4.5 * R
G' = 4.5 * G
B' = 4.5 * B
for R,G,B ≥ 0.018

Image Color Conversion
R' = 1.099 * R^{0.45} - 0.099
G' = 1.099 * G^{0.45} - 0.099
B' = 1.099 * B^{0.45} - 0.099

Note that the channel intensity values are normalized to fit in the range of [0..1]. The gamma value is equal to 1/0.45 = 2.22 in conformity with [ITU709] specification.

**Return Values**

- ippStsNoErr: Indicates no error. Any other value indicates an error.
- ippStsNullPtrErr: Indicates an error condition if pSrc, pDst, or pSrcDst is NULL.
- ippStsSizeErr: Indicates an error condition if roiSize has a field with a zero or negative value.
- ippStsGammaRangeErr: Indicates an error condition if the input data bounds are incorrect, that is vMax is less than or equal to vMin.

**GammaInv**

*Converts a gamma-corrected R'G'B' image back to the original RGB image.*

**Syntax**

**Case 1: Not-in-place operation on integer pixel-order data**

IppStatus ippiGammaInv_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

- 8u_C3R
- 16u_C3R
- 8u_AC4R
- 16u_AC4R

**Case 2: Not-in-place operation on integer planar data**

IppStatus ippiGammaInv_<mod>(const Ipp<datatype>* pSrc[3], int srcStep, Ipp<datatype>* pDst[3], int dstStep, IppiSize roiSize);

Supported values for mod:

- 8u_P3R
- 16u_P3R

**Case 3: Not-in-place operation on floating-point pixel-order data**

IppStatus ippiGammaInv_<mod>(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, Ipp32f vMin, Ipp32f vMax);

Supported values for mod:

- 32f_C3R
- 32f_AC4R

**Case 4: Not-in-place operation on floating-point planar data**

IppStatus ippiGammaInv_32f_P3R (const Ipp32f* pSrc[3], int srcStep, Ipp32f* pDst[3], int dstStep, IppiSize roiSize, Ipp32f vMin, Ipp32f vMax);
Case 5: In-place operation on integer pixel-order data

IppStatus ippiGammaInv_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppSize roiSize);

Supported values for mod:

  8u_C3IR   16u_C3IR
  8u_AC4IR  16u_AC4IR

Case 6: In-place operation on integer planar data

IppStatus ippiGammaInv_<mod>(Ipp<datatype>* pSrcDst[3], int srcDstStep, IppSize roiSize);

Supported values for mod:

  8u_IP3R   16u_IP3R

Case 7: In-place operation on floating-point pixel-order data

IppStatus ippiGammaInv_<mod>(Ipp32f* pSrcDst, int srcDstStep, IppSize roiSize, Ipp32f vMin, Ipp32f vMax);

Supported values for mod:

  32f_C3IR
  32f_AC4IR

Case 8: In-place operation on floating-point planar data

IppStatus ippiGammaInv_32f_IP3R (Ipp32f* pSrcDst[3], int srcDstStep, IppSize roiSize, Ipp32f vMin, Ipp32f vMax);

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters

pSrc

Pointer to the ROI in the pixel-order source image. Array of pointers to the ROI in each plane of the planar source image.

srcStep

Distance in bytes between starts of consecutive lines in the source image.

pDst

Pointer to the ROI in the pixel-order destination image. Array of pointers to the ROI in each plane of the planar destination image.

dstStep

Distance in bytes between starts of consecutive lines in the destination image.

pSrcDst

Pointer to the source and destination image ROI for the in-place operation.

srcDstStep

Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.

roiSize

Size of the source and destination ROI in pixels.
Minimum and maximum values of the input floating-point data.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts a gamma-corrected R'G'B' image back to the original RGB image. It uses the following equations:
for R',G',B' < 0.0812
R = R'/4.5
G = G'/4.5
B = B'/4.5
for R',G',B' ≥ 0.0812
\[ R = \left( \frac{R' + 0.099}{1.099} \right)^{2.22} \]
\[ G = \left( \frac{G' + 0.099}{1.099} \right)^{2.22} \]
\[ B = \left( \frac{B' + 0.099}{1.099} \right)^{2.22} \]
Note that the channel intensity values are normalized to fit in the range of [0..1]. The gamma value is equal to 1/0.45 = 2.22 in conformity with [ITU709] specification.

Return Values
- ippStsNoErr: Indicates no error. Any other value indicates an error.
- ippStsNullPtrErr: Indicates an error condition if pSrc, pDst, or pSrcDst is NULL.
- ippStsSizeErr: Indicates an error condition if roiSize has a field with a zero or negative value.
- ippStsGammaRangeErr: Indicates an error condition if the input data bounds are incorrect, that is, vMax is less than or equal to vMin.

Intensity Transformation
The functions described in this section perform different types of intensity transformation including reduction of the intensity levels in each channel of the image, intensity transformation using lookup tables, and mapping high dynamic range image (HDRI) into low dynamic range image (LDRI).

ReduceBitsGetBufferSize
Computes the size of the work buffer for the ippiReduceBits function.

Syntax
IppStatus ippiReduceBitsGetBufferSize(IppChannels ippChan, IppiSize roiSize, int noise, IppiDitherType dtype, int* pBufferSize);
Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

ippChan
Number of channels in the source images. Possible values:
ippC1, ippC3, or ippAC4.

roiSize
Size, in pixels, of the source images.

noise
Number specifying the amount of noise added (as a percentage of
the range [0..100]).

dtype
Type of dithering to be used. For the list of supported types,
refer to the ippiReduceBits function description.

pBufferSize
Pointer to the computed value of the buffer size, in bytes.

Description
The function computes the size of the work buffer, in bytes, for the ippiReduceBits function and stores the result in the pBufferSize parameter.

Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error or a
warning.

ippStsNullPtrErr
Indicates an error when any of the specified pointers is NULL.

ippStsSizeErr
Indicates an error when roiSize is less than, or equal to zero.

ippStsChannelErr
Indicates an error when ippChan has an illegal value.

ippStsDataTypeErr
Indicates an error when noise is less than 0, or greater than
100.

ippStsDataTypeErr
Indicates an error when the specified dithering type is not supported.

See Also
ReduceBits  Reduces the bit resolution of an image.

ReduceBits
Reduces the bit resolution of an image.
Syntax

Case 1: Operation on data of the same source and destination bit depths

IppStatus ippiReduceBits_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int noise, IppiDitherType dtype, int levels, Ipp8u* pBuffer);

Supported values for mod:

- 8u_C1R  16u_C1R  16s_C1R
- 8u_C3R  16u_C3R  16s_C3R
- 8u_C4R  16u_C4R  16s_C4R

IppStatus ippiReduceBits_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, int noise, IppiDitherType dtype, int levels, Ipp8u* pBuffer);

Supported values for mod:

- 8u_AC4R  16u_AC4R  16s_AC4R

Case 2: Operation on data of different source and destination bit depths

IppStatus ippiReduceBits_8u1u_C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstBitOffset, IppiSize roiSize, int noise, int seed, IppiDitherType dtype, Ipp8u threshold, Ipp8u* pBuffer);

IppStatus ippiReduceBits_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize roiSize, int noise, IppiDitherType dtype, int levels, Ipp8u* pBuffer);

Supported values for mod:

- 16u8u_C1R  16s8u_C1R  32f8u_C1R  32f16u_C1R  32f16s_C1R
- 16u8u_C3R  16s8u_C3R  32f8u_C3R  32f16u_C3R  32f16s_C3R
- 16u8u_C4R  16s8u_C4R  32f8u_C4R  32f16u_C4R  32f16s_C4R

IppStatus ippiReduceBits_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize roiSize, int noise, IppiDitherType dtype, int levels, Ipp8u* pBuffer);

Supported values for mod:

- 16u8u_AC4R  16s8u_AC4R  32f8u_AC4R  32f16u_AC4R  32f16s_AC4R

Include Files

ippcc.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Parameters

**pSrc**
Pointer to the source image ROI.

**srcStep**
Distance in bytes between starts of consecutive lines in the source image.

**pDst**
Pointer to the destination image ROI.

**dstStep**
Distance in bytes between starts of consecutive lines in the destination image.

**dstBitOffset**
Offset (in bits) in the first byte of the destination image row.

**roiSize**
Size of the source and destination ROI in pixels.

**noise**
The number specifying the amount of noise added. This parameter is set as a percentage of range [0..100].

**seed**
The seed value used by the pseudo-random number generation, should be set to 0.

**dtype**
The type of dithering to be used. The following types are supported:

- **ippDitherNone**
  No dithering is done

- **ippDitherStucki**
  The Stucki's error diffusion dithering algorithm is used

- **ippDitherFS**
  The Floyd-Steinberg error diffusion dithering algorithm is used

- **ippDitherJNN**
  The Jarvice-Judice-Ninke error diffusion dithering algorithm is used

- **ippDitherBayer**
  The Bayer's threshold dithering algorithm is used

**levels**
The number of output levels for halftoning (dithering); can be varied in the range $[2..(1<<depth)]$, where *depth* is the bit depth of the destination image.

**threshold**
Threshold level for Stucki's dithering for the function *ippiReduceBits_8ulu_C1R*.

**pBuffer**
Pointer to the buffer for internal calculations. To compute the size of the buffer, use the *ReduceBitsGetBufferSize* function.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function reduces the number of intensity levels in each channel of the source image *pSrc* and places the results in respective channels of the destination image *pDst*. Note that for floating point source data type, RGB values must be in the range [0..1].

The **levels** parameter sets the resultant number of intensity levels in each channel of the destination image.

If the **noise** value is greater than 0, some random noise is added to the threshold level used in computations. The amplitude of the noise signal is specified by the **noise** parameter set as a percentage of the destination image luminance range. For the 4x4 ordered dithering mode, the threshold value is determined by the dither matrix used, whereas for the error diffusion dithering mode the input threshold is set as half of the **range** value, where
\[\text{range} = \frac{(1<<\text{depth}) - 1}{(\text{levels} - 1)}\]

and \text{depth} is the bit depth of the source image.

For floating-point data type, \(\text{range} = 1.0/(\text{levels} - 1)\).

**8u to 1u conversion.** Source image is converted to a bitonal image. The function \text{ippiReduceBits\_8u1u\_C1R} supports only one dithering algorithm - Stucki's error diffusion. The destination image has a 8u data type, where each byte represents eight consecutive pixels of the bitonal image (1 bit per pixel). In this case, additional parameter \text{dstBitOffset} is required to specify the start position of the destination ROI buffer.

**Return Values**

- \text{ippStsNoErr} Indicates no error. Any other value indicates an error.
- \text{ippStsNullPtrErr} Indicates an error condition if \text{pSrc} or \text{pDst} is NULL.
- \text{ippStsSizeErr} Indicates an error condition if \text{roiSize} has a field with a zero or negative value.
- \text{ippStsNoiseValErr} Indicates an error condition if \text{noise} has an illegal value.
- \text{ippStsDitherTypeErr} Indicates an error condition if the specified dithering type is not supported.
- \text{ippStsDitherLevelsErr} Indicates an error condition if \text{levels} value is out of admissible range.
- \text{ippStsMemAllocErr} Indicates an error condition if memory allocation fails.

**See Also**

- \text{ReduceBitsGetBufferSize} Computes the size of the work buffer for the \text{ippiReduceBits} function.

**LUT\_GetSize**

*Computes the size of the LUT specification structure.*

**Syntax**

\begin{verbatim}
IppStatus ippiLUT_GetSize(IppiInterpolationType interpolation, IppDataType dataType,
                     IppChannels channels, IppiSize roiSize, const int nLevels[], int* pSpecSize);
\end{verbatim}

**Include Files**

ippi.h

**Domain Dependencies**

- Headers: ippcore.h, ippvm.h, ipps.h
- Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- \text{interpolation} Interpolation algorithm, possible values are:
  - \text{ippNearest} Nearest neighbor interpolation.
  - \text{ippCubic} Cubic interpolation.
  - \text{ippLinear} Linear interpolation.
dataType

Data type of the image. Possible values are ipp8u, ipp16u, ipp16s, or ipp32f.

channels

Number of channels in the image. Possible values are: ippC1, ippC3, ippC4, or ippAC4.

roiSize

Size, in pixels, of the destination ROI.

nLevels

Number of levels, separate for each channel.

pSpecSize

Pointer to the computed size, in bytes, of the specification structure.

Description

This function computes the size of the specification structure for the ippiLUT function. The result is stored in the pSpecSize parameter.

For an example on how to use this function, refer to the example provided with the ippiLUT function description.

Return Values

ippStsNoErr

Indicates no error.

ippStsNullPtrErr

Indicates an error when any of the specified pointers is NULL.

ippStsSizeErr

Indicates an error when roiSize has a field with a value less than 1.

ippStsChannelErr

Indicates an error when channel has an illegal value.

ippStsDataTypeErr

Indicates an error when dataType has an illegal value.

ippStsInterpolationErr

Indicates an error when interpolation has an illegal value.

See Also

LUT MODIFIED API. Maps an image by applying intensity transformation.

LUT_Init

Initializes the LUT specification structure.

Syntax

IppStatus ippiLUT_Init_8u(IppiInterpolationType interpolation, IppChannels channels, IppiSize roiSize, const Ipp32s* pValues[], const Ipp32s* pLevels[], int nLevels[], IppiLUT_Spec* pSpec);

IppStatus ippiLUT_Init_16u(IppiInterpolationType interpolation, IppChannels channels, IppiSize roiSize, const Ipp32s* pValues[], const Ipp32s* pLevels[], int nLevels[], IppiLUT_Spec* pSpec);

IppStatus ippiLUT_Init_16s(IppiInterpolationType interpolation, IppChannels channels, IppiSize roiSize, const Ipp32s* pValues[], const Ipp32s* pLevels[], int nLevels[], IppiLUT_Spec* pSpec);

IppStatus ippiLUT_Init_32f(IppiInterpolationType interpolation, IppChannels channels, IppiSize roiSize, const Ipp32f* pValues[], const Ipp32f* pLevels[], int nLevels[], IppiLUT_Spec* pSpec);
Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

interpolation
Interpolation algorithm, possible values are:
  ippNearest Nearest neighbor interpolation.
  ippCubic Cubic interpolation.
  ippLinear Linear interpolation.

channels
Number of channels in the image. Possible values are: ippC1, ippC3, ippC4, or ippAC4.

roiSize
Size, in pixels, of the destination ROI.

pValues
Pointer to the array with intensity values, separate for each channel.

pLevels
Pointer to the array with level values, separate for each channel.

nLevels
Number of levels, separate for each channel.

pSpec
Pointer to the LUT specification structure.

Description
This function initializes the specification structure for the ippiLUT function. To compute the size of the structure, use the ippiLUTGetSize function.

Length of the pLevels and pValues arrays is defined by the nLevels parameter. Number of level and intensity values are nLevels-1.

The interpolation parameter defines the mapping algorithm for the LUT function:

- **ippiNearest**: Every source pixel \( p_{Src}(x,y) \) from the range \([p_{Levels}[k], p_{Levels}[k+1])\) is mapped to the destination pixel \( p_{Dst}(x,y) \) which value is equal to \( p_{Values}[k] \).

- **ippiLinear**: Every source pixel \( p_{Src}(x, y) \) from the range \([p_{Levels}[k], p_{Levels}[k+1])\) is mapped to the destination pixel \( p_{Dst}(x, y) \) which value is computed according to the following formula:
  \[
p_{Dst}(x, y) = p_{Values}[k] + (p_{Src}(x, y) - p_{Levels}[k]) * (p_{Values}[k+1] - p_{Values}[k]) / (p_{Levels}[k+1] - p_{Levels}[k])
  \]

- **ippiCubic**: Every source pixel \( p_{Src}(x,y) \) from the range \([p_{Levels}[k], p_{Levels}[k+1])\) is mapped to the destination pixel \( p_{Dst}(x,y) \) which value is computed as
  \[
p_{Dst}(x,y) = A * p_{Src}(x,y)^3 + B * p_{Src}(x,y)^2 + C * p_{Src}(x,y) + D.
  \]

The function operates on the assumption that the cubic polynomial curve passes through the following four points:

- \([p_{Levels}[k-1], p_{Levels}[k-1])\)
- \([p_{Levels}[k], p_{Levels}[k])\)
- \([p_{Levels}[k+1], p_{Levels}[k+1])\)
Based on that, coefficients A, B, C, D are computed by solving the following set of linear equations:

\[
\begin{align*}
A\cdot pLevels[k-1]^3 &+ B\cdot pLevels[k-1]^2 + C\cdot pLevels[k-1] + D = pValues[k-1] \\
A\cdot pLevels[k]^3 &+ B\cdot pLevels[k]^2 + C\cdot pLevels[k] + D = pValues[k] \\
A\cdot pLevels[k+1]^3 &+ B\cdot pLevels[k+1]^2 + C\cdot pLevels[k+1] + D = pValues[k+1] \\
A\cdot pLevels[k+2]^3 &+ B\cdot pLevels[k+2]^2 + C\cdot pLevels[k+2] + D = pValues[k+2]
\end{align*}
\]

Pixels in the pSrc image that are not in the range \([pLevels[0], pLevels[nLevels-1])\) are copied to the pDst image without any transformation.

For an example on how to use this function, refer to the example provided with the ippiLUT function description.

### Return Values

- **ippStsNoErr**
  - Indicates no error.

- **ippStsNullPtrErr**
  - Indicates an error when any of the specified pointers is NULL.

- **ippStsSizeErr**
  - Indicates an error when roiSize has a field with a value less than 1.

- **ippStsChannelErr**
  - Indicates an error when channel has an illegal value.

- **ippStsLUTNofLevelsErr**
  - Indicates an error when nLevels is less than 2.

- **ippStsInterpolationErr**
  - Indicates an error when interpolation has an illegal value.

### See Also

- **LUT MODIFIED API.** Maps an image by applying intensity transformation.
- **LUT_GetSize** Computes the size of the LUT specification structure.

### LUT

**MODIFIED API.** Maps an image by applying intensity transformation.

### Syntax

**Case 1: Not-in-place operation on one-channel integer data**

```c
IppStatus ippiLUT_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiLUT_Spec* pSpec);
```

Supported values for **mod**:

- 8u_C1R
- 16u_C1R
- 16s_C1R

**Case 2: Not-in-place operation on multi-channel integer data**

```c
IppStatus ippiLUT_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiLUT_Spec* pSpec);
```

Supported values for **mod**:

- 8u_C3R
- 16u_C3R
- 16s_C3R
- 8u_AC4R
- 16u_AC4R
- 16s_AC4R
IppStatus ippiLUT_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiLUT_Spec* pSpec);

Supported values for mod:

8u_C4R 16u_C4R 16s_C4R

Case 3: Not-in-place operation on one-channel floating-point data
IppStatus ippiLUT_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiLUT_Spec* pSpec);

Case 4: Not-in-place operation on multi-channel floating-point data
IppStatus ippiLUT_<mod>(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiLUT_Spec* pSpec);

Supported values for mod:

32f_C3R 32f_AC4R

IppStatus ippiLUT_32f_C4R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiLUT_Spec* pSpec);

Case 5: In-place operation on one-channel integer data
IppStatus ippiLUT_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, IppiLUT_Spec* pSpec);

Supported values for mod:

8u_C1IR 16u_C1IR 16s_C1IR

Case 6: In-place operation on multi-channel integer data
IppStatus ippiLUT_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, IppiLUT_Spec* pSpec);

Supported values for mod:

8u_C3IR 16u_C3IR 16s_C3IR 8u_AC4IR 16u_AC4IR 16s_AC4IR

IppStatus ippiLUT_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, IppiLUT_Spec* pSpec);

Supported values for mod:

8u_C4IR 16u_C4IR 16s_C4IR

Case 7: In-place operation on one-channel floating-point data
IppStatus ippiLUT_32f_C1IR(Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize, IppiLUT_Spec* pSpec);

Case 8: In-place operation on multi-channel floating-point data
IppStatus ippiLUT_<mod>(Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize, IppiLUT_Spec* pSpec);

Supported values for mod:

32f_C3IR
IppStatus ippiLUT_32f_C4IR(Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize, IppiLUT_Spec* pSpec);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance, in bytes, between the starting points of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance, in bytes, between the starting points of consecutive lines in the destination image.
- **pSrcDst**: Pointer to the source and destination mage ROI for the in-place operation.
- **srcDstStep**: Distance, in bytes, between the starting points of consecutive lines in the source and destination image for the in-place operation.
- **roiSize**: Size of the source ROI, in pixels.
- **pSpec**: Pointer to the LUT specification structure.

Description

**Important** The API of this function has been modified in Intel IPP 9.0 release.

This function operates with ROI (see Regions of Interest in Intel IPP).

Before using this function, you need to compute the size of the specification structure using the LUTGetSize function and initialize the structure using LUT_Init.

This function performs intensity transformation of the source image pSrc using the lookup table (LUT) specified by the arrays pLevels, pValues, and interpolation type specified in the LUT_Init function when pSpec is initialized.

The figure below shows particular curves that are used in all the ippiLUT function flavors for mapping. The level values are 0, 64, 128, 192, 256; the intensity values are 20, 60, 160, 180, 230.
Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr
Indicates an error when any of the specified pointers is NULL.

ippStsSizeErr
Indicates an error when roiSize has a field with a value less than 1.

ippStsStepErr
Indicates an error when srcStep, dstStep, or srcDstStep has a zero or negative value.

ippStsBadArgErr
Indicates an error when pSpec initialization is incorrect.

Example

The code example below demonstrates how to use LUTGetSize, LUT_Init, andippiLUT functions.

```c
#include "ippcore.h"
#include "ippi.h"
#include "t_genPRINT.h"

void func_LUTLinear()
{
    IppStatus status;
    Ipp32f pSrc[8*8];
    int srcStep = 8*sizeof(Ipp32f);
    IppiSize roiSize = (8, 8);

    Ipp32f pDst[8*8];
    int dstStep = 8*sizeof(Ipp32f);
    Ipp32f pLevels[5] = {0.0, 0.128, 0.256, 0.512, 1.0};
    const Ipp32f *ppLevels[1] = { pLevels };
    Ipp32f pValues[5] = {0.2, 0.4, 0.6, 0.8, 1.0};
    const Ipp32f *ppValues[1] = { pValues };
    int nLevels[1] = {5};
    int specSize;
    IppiLUT_Spec* pSpec;

    status =ippiImageJaehne_32f_C1R( pSrc, srcStep, roiSize );
    printf_32f_2D( "pSrc:", pSrc, roiSize, roiSize.width*sizeof(Ipp32f), status );
```
ippiLUTGetSize( ippLinear, ipp32f, ippC1, roiSize, nLevels, &specSize );

pSpec = (IppiLUT_Spec*)ippMalloc( specSize );

ippiLUT_Init_32f( ippLinear, ippC1, roiSize, ppValues, ppLevels, nLevels, pSpec );
status =ippiLUT_32f_C1R( pSrc, srcStep, pDst, dstStep, roiSize, pSpec );
printf_32f_2D( "pDst:", pDst, roiSize, roiSize.width*sizeof(Ipp32f), status );
ippiFree( pSpec );
}

Result:

pSrc:
0.00 0.26 0.65 0.82 0.82 0.65 0.26 0.00
0.26 0.82 1.00 0.98 0.98 1.00 0.82 0.26
0.65 1.00 0.89 0.74 0.74 0.89 1.00 0.65
0.82 0.98 0.74 0.55 0.55 0.74 0.98 0.82
0.82 0.98 0.74 0.55 0.55 0.74 0.98 0.82
0.65 1.00 0.89 0.74 0.74 0.89 1.00 0.65
0.26 0.82 1.00 0.98 0.98 1.00 0.82 0.26
0.00 0.26 0.65 0.82 0.82 0.65 0.26 0.00

pDst:
0.20 0.61 0.85 0.93 0.93 0.85 0.61 0.20
0.61 0.93 1.00 0.99 0.99 1.00 0.93 0.61
0.85 1.00 0.95 0.89 0.89 0.95 1.00 0.85
0.93 0.99 0.89 0.82 0.82 0.89 0.99 0.93
0.93 0.99 0.89 0.82 0.82 0.89 0.99 0.93
0.85 1.00 0.95 0.89 0.89 0.95 1.00 0.85
0.61 0.93 1.00 0.99 0.99 1.00 0.93 0.61
0.20 0.61 0.85 0.93 0.93 0.85 0.61 0.20

See Also
Regions of Interest in Intel IPP
LUTGetSize Computes the size of the LUT specification structure.
LUTInit Initializes the LUT specification structure.

LUTPalette, LUTPaletteSwap
Maps an image by applying intensity transformation in accordance with a palette table.

Syntax
Case 1: Operations on one-channel data

IppStatus ippiLUTPalette_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep,
Ipp<dstDatatype>* pDst, int dstStep, IppiSize roiSize, const Ipp<dstDatatype>* pTable, int nBitSize);

Supported values for mod:

<table>
<thead>
<tr>
<th>8u</th>
<th>16u</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1R</td>
<td>C1R</td>
</tr>
<tr>
<td>8u32</td>
<td>16u8</td>
</tr>
<tr>
<td></td>
<td>C1R</td>
</tr>
<tr>
<td></td>
<td>16u32</td>
</tr>
</tbody>
</table>
IppStatusippiLUTPalette_<mod>(const Ipp<srcDatatype>*>* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, const Ipp8u* pTable, int nBitSize);

Supported values for mod:
8u24u_C1R 16u24u_C1R

Case 2: Operations on multi-channel data
IppStatusippiLUTPalette_<mod>(const Ipp<datatype>*>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp<datatype>** const pTable[3], int nBitSize);

Supported values for mod:
8u_C3R 16u_C3R
8u_AC4R 16u_AC4R

IppStatusippiLUTPalette_<mod>(const Ipp<datatype>*>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp<datatype>** const pTable[4], int nBitSize);

Supported values for mod:
8u_C4R 16u_C4R

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pSrc  Pointer to the source image ROI.
srcStep  Distance in bytes between starts of consecutive lines in the source image.
pDst  Pointer to the destination image ROI.
dstStep  Distance in bytes between starts of consecutive lines in the destination image.
roiSize  Size of the source ROI in pixels.
pTable  Pointer to the palette table, or an array of pointers to the palette tables for each source channel.
nBitSize  Number of significant bits in the source image.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).

The function ippiLUTPalette performs intensity transformation of the source image pSrc using the palette lookup table pTable. This table is a vector with $2^{nBitSize}$ elements that contain intensity values specified by the user. The function uses nBitSize lower bits of intensity value of each source pixel as an index in the
and assigns the correspondent intensity value from the table to the respective pixel in the destination image \( p_{Dst} \). The number of significant bits \( n_{BitSize} \) should be in the range \([1, 8]\) for functions that operate on \( 8u \) source images, and \([1, 16]\) for functions that operate on \( 16u \) source images.

Some function flavors that operate on the 3-channel source image additionally create a 4-th channel - alpha channel - in the destination image and place it at first position. The channel values of the alpha channel can be set to the arbitrary constant value \( alphaValue \). If this value is less than 0 or greater than the upper boundary of the data range, the channel values are not set.

The function flavor \( \text{ippiLUTPaletteSwap} \) reverses the order of channels in the destination image.

**Return Values**

- \( \text{ippStsNoErr} \): Indicates no error. Any other value indicates an error or a warning.
- \( \text{ippStsNullPtrErr} \): Indicates an error when any of the specified pointers is \( \text{NULL} \).
- \( \text{ippStsSizeErr} \): Indicates an error condition if \( roiSize \) has a field with a zero or negative value.
- \( \text{ippStsOutOfRangeErr} \): Indicates an error if \( n_{BitSize} \) is out of the range.

**Example**

The code example below shows how to use the function \( \text{ippiLUTPalette}_8u32u\_C1R \).

```c
#include "ippcore.h"
#include "ippi.h"
#include "t_genPRINT.h"

void func_LUTPalette()
{
    IppStatus status;
    Ipp8u pSrc[8*8];
    int srcStep = 8*sizeof(Ipp8u);
    IppiSize roiSize = {8, 8};

    Ipp32u pDst[8*8];
    int dstStep = 8*sizeof(Ipp32f);
    int nBitSize = 3;
    Ipp32u pTable[8] ={1, 2, 3, 4, 5, 6, 7, 8} ;

    status = ippiImageJaehne_8u_C1R( pSrc, srcStep, roiSize);
    printf_8u_2D( "pSrc:", pSrc, roiSize, srcStep, status );

    status = ippiLUTPalette_8u32u_C1R( pSrc, srcStep, pDst, dstStep, roiSize, pTable, nBitSize);
    printf_32u_2D( "pDst:", pDst, roiSize, dstStep, status );
}
```

**Result:**

\( \text{pSrc:} \)

```
0 67 165 209 209 165 67 0
67 209 255 250 255 209 67
165 255 226 188 188 226 255 165
209 250 188 140 140 188 250 209
209 250 188 140 188 250 209
165 255 226 188 188 226 255 165
67 209 255 250 255 209 67
```

**Image Color Conversion**
ToneMapLinear, ToneMapMean
Maps an HDRI image to the LDRI image.

Syntax
IppStatus ippiToneMapLinear_32f8u_C1R(const Ipp32f* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiToneMapMean_32f8u_C1R(const Ipp32f* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize);

Include Files
ippcc.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
pSrc
Pointer to the ROI in the HDRI source image.

srcStep
Distance in bytes between starts of consecutive lines in the source image.

pDst
Pointer to the ROI in the LDRI destination image.

dstStep
Distance in bytes between starts of consecutive lines in the destination image.

roiSize
Size of the source and destination ROI in pixels.

Description
They both operate with ROI (see Regions of Interest in Intel IPP).

These functions convert the source high dynamic range image (HDRI) pSrc into low dynamic range image (LDRI) pDst. Pixel values of the source image must be positive.

The function ippiToneMapLinear implements the Linear Scale-Factor method converting each source pixel pSrc[i] in accordance with the formula:

\[ p_{\text{Src}[i]} = \frac{p_{\text{Src}[i]}}{L_{\text{max}}}, \quad L_{\text{max}} = \max\{p_{\text{Src}[i]}\}. \]

The function ippiToneMapMean implements the Mean Value method converting each source pixel pSrc[i] in accordance with the formula:

\[ p_{\text{Dst}[i]} = \frac{1}{L_{\text{max}}} \sum_{i=0}^{L_{\text{max}}} p_{\text{Src}[i]}, \quad L_{\text{max}} = \max\{p_{\text{Src}[i]}\}. \]
\( p_{\text{Src}[i]} = 0.5 \cdot p_{\text{Src}[i]} / L_{\text{ave}}, \ L_{\text{ave}} = \text{average}(p_{\text{Src}[i]}). \)

If the value of \( L_{\text{max}} \) or \( L_{\text{ave}} \) is less than 0, then the function does not perform the operation and returns the warning message.

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**
  Indicates an error condition if \( p_{\text{Src}} \) or \( p_{\text{Dst}} \) is NULL.

- **ippStsSizeErr**
  Indicates an error condition if \( \text{roiSize} \) has a field with a zero or negative value.

- **ippStsNoOperation**
  Indicates a warning if the values of \( L_{\text{max}} \) or \( L_{\text{ave}} \) are less than 0.
Threshold and Compare Operations

This chapter describes the Intel® IPP image processing functions that operate on a pixel-by-pixel basis: threshold and compare functions.

Thresholding

The threshold functions change pixel values depending on whether they are less or greater than the specified threshold.

The type of comparison operation used to threshold pixel values is specified by the ippCmpOp parameter; this operation can be either “greater than” or “less than” (see Structures and Enumerators in Chapter 2 for more information). For some thresholding functions the type of comparison operation is fixed.

If an input pixel value satisfies the compare condition, the corresponding output pixel is set to the fixed value that is specific for a given threshold function flavor. Otherwise, it is either not changed, or set to another fixed value, which is defined in a particular function description.

For images with multi-channel data, the compare conditions should be set separately for each channel.

Threshold

Performs thresholding of pixel values in an image buffer.

Syntax

Case 1: Not-in-place operation on one-channel data

IppStatus ippiThreshold_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, Ipp<datatype> threshold, IppCmpOp ippCmpOp);

Supported values for mod:

8u_C1R   16u_C1R   16s_C1R   32f_C1R

Case 2: Not-in-place operation on multi-channel data

IppStatus ippiThreshold_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp<datatype> threshold[3], IppCmpOp ippCmpOp);

Supported values for mod:

8u_C3R   16u_C3R   16s_C3R   32f_C3R
8u_AC4R  16u_AC4R  16s_AC4R  32f_AC4R
Case 3: In-place operation on one-channel data

IppStatus ippiThreshold_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp<datatype> threshold, IppCmpOp ippCmpOp);

Supported values for mod:

8u_C1IR  16u_C1IR  16s_C1IR  32f_C1IR

Case 4: In-place operation on multi-channel data

IppStatus ippiThreshold_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, const Ipp<datatype> threshold[3], IppCmpOp ippCmpOp);

Supported values for mod:

8u_C3IR  16u_C3IR  16s_C3IR  32f_C3IR

8u_AC4IR  16u_AC4IR  16s_AC4IR  32f_AC4IR

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc      Pointer to the source image ROI.
srcStep   Distance in bytes between starts of consecutive lines in the source image.
pDst      Pointer to the destination image ROI.
dstStep   Distance in bytes between starts of consecutive lines in the destination image.
pSrcDst   Pointer to the source and destination image ROI (for the in-place operation).
srcDstStep Distance in bytes between starts of consecutive lines in the source and destination image buffer (for the in-place operation).
roiSize   Size of the source and destination ROI in pixels.
threshold The threshold level value to use for each pixel. In case of multi-channel data, an array of threshold values for each color channel is used.
ippCmpOp  The operation specified for comparing pixel values and the threshold. Comparison for either “less than” or “greater than” can be used.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function thresholds pixels in the source image \( pSrc \) using the specified level \( \text{threshold} \). Pixel values in the source image are compared to the \( \text{threshold} \) value according to the type of comparison operation specified in the \( \text{ippCmpOp} \). The following values for \( \text{ippCmpOp} \) are possible:

- \text{ippCmpLess} specifies the "less than" comparison and defines the \( \text{threshold} \) value as a lower bound. Comparison is performed by the following formula:

\[
\begin{align*}
    pDst[n] = \begin{cases} 
        \text{threshold}, & pSrc[n] < \text{threshold} \\
        pSrc[n], & \text{otherwise}
    \end{cases}
\end{align*}
\]

- \text{ippCmpGreater} specifies the "greater than" comparison and defines the \( \text{threshold} \) value as an upper bound. Comparison is performed by the following formula:

\[
\begin{align*}
    pDst[n] = \begin{cases} 
        \text{threshold}, & pSrc[n] > \text{threshold} \\
        pSrc[n], & \text{otherwise}
    \end{cases}
\end{align*}
\]

If the result of comparison is true, the corresponding output pixel is set to the \( \text{threshold} \) value. Otherwise, it is set to the source pixel value.

**Return Values**

- \text{ippStsNoErr} Indicates no error. Any other value indicates an error or a warning.
- \text{ippStsNullPtrErr} Indicates an error condition if one of the specified pointer is null.
- \text{ippStsSizeErr} Indicates an error condition if \( \text{roiSize} \) has a field with zero or negative value.
- \text{ippStsStepErr} Indicates an error condition if \( \text{srcStep}, \text{dstStep}, \) or \( \text{srcDstStep} \) has a zero or negative value.
- \text{ippStsNotSupportedModeErr} Indicates an error if the comparison mode is not supported.

**Example**

The code example below shows how to use the \text{ippiThreshold_8u_C1R} function.

```c
void func_threshold()
{
    IppiSize ROI = {5,4};
    Ipp8u src[9*4] = {1, 2, 4, 8, 16, 8, 4, 2, 1,
                      1, 2, 4, 8, 16, 8, 4, 2, 1,
                      1, 2, 4, 8, 16, 8, 4, 2, 1,
                      1, 2, 4, 8, 16, 8, 4, 2, 1};
    Ipp8u dst[9*4];
    Ipp8u threshold = 6;
    ippiThreshold_8u_C1R(src, 9, dst, 9, ROI, threshold, ippCmpGreater);
}
```

**Result:**

<table>
<thead>
<tr>
<th>dst</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 4 6 6 8 4 2 1</td>
</tr>
<tr>
<td>1 2 4 6 6 8 4 2 1</td>
</tr>
<tr>
<td>1 2 4 6 6 8 4 2 1</td>
</tr>
<tr>
<td>1 2 4 6 6 8 4 2 1</td>
</tr>
</tbody>
</table>
**Threshold_GT**

*Performs thresholding of pixel values in an image, using the comparison for “greater than”.***

**Syntax**

**Case 1: Not-in-place operation on one-channel data**

IppStatus ippiThreshold_GT_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, Ipp<datatype> threshold);

Supported values for mod:

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R

**Case 2: Not-in-place operation on multi-channel data**

IppStatus ippiThreshold_GT_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp<datatype> threshold[3]);

Supported values for mod:

- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 8u_AC4R
- 16u_AC4R
- 16s_AC4R
- 32f_AC4R

**Case 3: In-place operation on one-channel data**

IppStatus ippiThreshold_GT_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp<datatype> threshold);

Supported values for mod:

- 8u_C1IR
- 16u_C1IR
- 16s_C1IR
- 32f_C1IR

**Case 4: In-place operation on multi-channel data**

IppStatus ippiThreshold_GT_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, const Ipp<datatype> threshold[3]);

Supported values for mod:

- 8u_C3IR
- 16u_C3IR
- 16s_C3IR
- 32f_C3IR
- 8u_AC4IR
- 16u_AC4IR
- 16s_AC4IR
- 32f_AC4IR

**Include Files**

ippi.h

**Domain Dependencies**

*Headers: ippcore.h, ippvm.h, ipps.h*

*Libraries: ippcore.lib, ippvm.lib, ipps.lib*
**Parameters**

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **pSrcDst**: Pointer to the source and destination image ROI (for the in-place operation).
- **srcDstStep**: Distance in bytes between starts of consecutive lines in the source and destination image buffer (for the in-place operation).
- **roiSize**: Size of the source and destination ROI in pixels.
- **threshold**: The threshold level value to use for each pixel. In case of multi-channel data, an array of threshold values for each color channel is used.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function performs thresholding of pixels in the source image `pSrc` using the specified level `threshold`. Pixel values in the source image are compared to the `threshold` value for “greater than”.

If the result of the compare is true, the corresponding output pixel is set to the `threshold` value. Otherwise, it is set to the source pixel value.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointer is NULL.
- **ippStsSizeErr**: Indicates an error condition if `roiSize` has a field with zero or negative value.
- **ippStsStepErr**: Indicates an error condition if `srcStep`, `dstStep`, or `srcDstStep` has a zero or negative value.

**Threshold_LT**

Performs thresholding of pixel values in an image buffer, using the comparison for “less than”.

**Syntax**

**Case 1: Not-in-place operation on one-channel data**

```c
IppStatus ippiThreshold_LT_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, Ipp<datatype> threshold);
```

Supported values for `mod`:

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R
Case 2: Not-in-place operation on multi-channel data

IppStatus ippiThreshold_LT_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp<datatype> threshold[3]);

Supported values for mod:

<table>
<thead>
<tr>
<th>8u_C3R</th>
<th>16u_C3R</th>
<th>16s_C3R</th>
<th>32f_C3R</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_AC4R</td>
<td>16u_AC4R</td>
<td>16s_AC4R</td>
<td>32f_AC4R</td>
</tr>
</tbody>
</table>

Case 3: In-place operation on one-channel data

IppStatus ippiThreshold_LT_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp<datatype> threshold);

Supported values for mod:

| 8u_C1IR | 16u_C1IR | 16s_C1IR | 32f_C1IR |

Case 4: In-place operation on multi-channel data

IppStatus ippiThreshold_LT_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, const Ipp<datatype> threshold[3]);

Supported values for mod:

<table>
<thead>
<tr>
<th>8u_C3IR</th>
<th>16u_C3IR</th>
<th>16s_C3IR</th>
<th>32f_C3IR</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_AC4IR</td>
<td>16u_AC4IR</td>
<td>16s_AC4IR</td>
<td>32f_AC4IR</td>
</tr>
</tbody>
</table>

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- pSrc
  - Pointer to the source image ROI.
- srcStep
  - Distance in bytes between starts of consecutive lines in the source image.
- pDst
  - Pointer to the destination image ROI.
- dstStep
  - Distance in bytes between starts of consecutive lines in the destination image.
- pSrcDst
  - Pointer to the source and destination image ROI (for the in-place operation).
- srcDstStep
  - Distance in bytes between starts of consecutive lines in the source and destination image buffer (for the in-place operation).
- roiSize
  - Size of the source and destination ROI in pixels.
The threshold level value to use for each pixel. In case of multi-channel data, an array of threshold values for each color channel is used.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function performs thresholding of pixels in the source image \( pSrc \) using the specified level \( \text{threshold} \). Pixel values in the source image are compared to the \( \text{threshold} \) value for “less than”. If the result of the compare is true, the corresponding output pixel is set to the \( \text{threshold} \) value. Otherwise, it is set to the source pixel value.

Return Values
- \( \text{ippStsNoErr} \): Indicates no error. Any other value indicates an error or a warning.
- \( \text{ippStsNullPtrErr} \): Indicates an error condition if one of the specified pointer is NULL.
- \( \text{ippStsSizeErr} \): Indicates an error condition if \( \text{roiSize} \) has a field with zero or negative value.
- \( \text{ippStsStepErr} \): Indicates an error condition if \( \text{srcStep} \), \( \text{dstStep} \), or \( \text{srcDstStep} \) has a zero or negative value.

Threshold_Val
Performs thresholding of pixel values in an image buffer. Pixels that satisfy the compare condition are set to a specified value.

Syntax

Case 1: Not-in-place operation on one-channel data

IppStatus ippiThreshold_Val_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, Ipp<datatype> threshold, Ipp<datatype> value, IppCmpOp ippCmpOp);

Supported values for \( \text{mod} \):

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R

Case 2: Not-in-place operation on multi-channel data

IppStatus ippiThreshold_Val_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp<datatype> threshold[3], const Ipp<datatype> value[3], IppCmpOp ippCmpOp);

Supported values for \( \text{mod} \):

- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R

- 8u_AC4R
- 16u_AC4R
- 16s_AC4R
- 32f_AC4R
Case 3: In-place operation on one-channel data
IppStatus ippiThreshold_Val_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppSize roiSize, Ipp<datatype> threshold, Ipp<datatype> value, IppCmpOp ippCmpOp);

Supported values for mod:

8u_C1IR   16u_C1IR   16s_C1IR   32f_C1IR

Case 4: In-place operation on multi-channel data
IppStatus ippiThreshold_Val_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppSize roiSize, const Ipp<datatype> threshold[3], const Ipp<datatype> value[3], IppCmpOp ippCmpOp);

Supported values for mod:

8u_C3IR   16u_C3IR   16s_C3IR   32f_C3IR
8u_AC4IR   16u_AC4IR   16s_AC4IR   32f_AC4IR

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc
Pointer to the source image ROI.
srcStep
Distance in bytes between starts of consecutive lines in the source image.
pDst
t Pointer to the destination image ROI.
dstStep
Distance in bytes between starts of consecutive lines in the destination image.
pSrcDst
Pointer to the source and destination image ROI (for the in-place operation).
srcDstStep
Distance in bytes between starts of consecutive lines in the source and destination image buffer (for the in-place operation).
roiSize
Size of the source and destination ROI in pixels.
threshold
The threshold value to use for each pixel. In case of multi-channel data, an array of 3 threshold values (one for each color channel) is used.
value
The output value to be set for each pixel that satisfies the compare condition. In case of multi-channel data, an array of 3 output values (one for each color channel) is used.
ippCmpOp
The operation to use for comparing pixel values and the threshold. Comparison for either “less than” or “greater than” can be used.
Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function thresholds pixels in the source image \( pSrc \) using the specified level \( \text{threshold} \). Pixel values in the source image are compared to the \( \text{threshold} \) value using the \( \text{ippCmpOp} \) comparison operation. If the result of the compare is true, the corresponding output pixel is set to the specified \( \text{value} \). Otherwise, it is set to the source pixel value.

Return Values

- \( \text{ippStsNoErr} \) Indicates no error. Any other value indicates an error or a warning.
- \( \text{ippStsNullPtrErr} \) Indicates an error condition if one of the specified pointer is NULL.
- \( \text{ippStsSizeErr} \) Indicates an error condition if \( \text{roiSize} \) has a field with zero or negative value.
- \( \text{ippStsStepErr} \) Indicates an error condition if \( \text{srcStep} \), \( \text{dstStep} \), or \( \text{srcDstStep} \) has a zero or negative value.

Threshold_GTVal

Performs thresholding of pixel values in an image.

Pixels that are greater than \( \text{threshold} \), are set to a specified \( \text{value} \).

Syntax

Case 1: Not-in-place operation on one-channel data

\[
\text{IppStatus} \ ippiThreshold_GTVal_{\text{mod}}(\text{const Ipp<datatype>*} \ pSrc, \text{int} \ srcStep, \text{Ipp<datatype>*} \ pDst, \text{int} \ dstStep, \text{IppiSize} \ roiSize, \text{Ipp<datatype>} \ threshold, \text{Ipp<datatype>} \ value);
\]

Supported values for \( \text{mod} \):

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R

Case 2: Not-in-place operation on multi-channel data

\[
\text{IppStatus} \ ippiThreshold_GTVal_{\text{mod}}(\text{const Ipp<datatype>*} \ pSrc, \text{int} \ srcStep, \text{Ipp<datatype>*} \ pDst, \text{int} \ dstStep, \text{IppiSize} \ roiSize, \text{const Ipp<datatype>} \ threshold[3], \text{const Ipp<datatype>} \ value[3]);
\]

Supported values for \( \text{mod} \):

- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 8u_AC4R
- 16u_AC4R
- 16s_AC4R
- 32f_AC4R
IppStatusippiThreshold_GTVal<mod>(const Ipp<datatype> * pSrc, int srcStep,
Ipp<datatype> * pDst, int dstStep, IppiSize roiSize, const Ipp<datatype> threshold[4],
const Ipp<datatype> value[4]);

Supported values for mod:

8u_C4R  16u_C4R  16s_C4R  32f_C4R

Case 3: In-place operation on one-channel data
IppStatusippiThreshold_GTVal<mod>(Ipp<datatype> * pSrcDst, int srcDstStep, IppiSize
roiSize, Ipp<datatype> threshold, Ipp<datatype> value);

Supported values for mod:

8u_C1IR  16u_C1IR  16s_C1IR  32f_C1IR

Case 4: In-place operation on multi-channel data
IppStatusippiThreshold_GTVal<mod>(Ipp<datatype> * pSrcDst, int srcDstStep, IppiSize
roiSize, const Ipp<datatype> threshold[3], const Ipp<datatype> value[3]);

Supported values for mod:

8u_C3IR  16u_C3IR  16s_C3IR  32f_C3IR
8u_AC4IR  16u_AC4IR  16s_AC4IR  32f_AC4IR

IppStatusippiThreshold_GTVal<mod>(Ipp<datatype> * pSrcDst, int srcDstStep, IppiSize
roiSize, const Ipp<datatype> threshold[4], const Ipp<datatype> value[4]);

Supported values for mod:

8u_C4IR  16u_C4IR  16s_C4IR  32f_C4IR

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc  Pointer to the source image ROI.
srcStep  Distance in bytes between starts of consecutive lines in the
         source image.
pDst  Pointer to the destination image ROI.
dstStep  Distance in bytes between starts of consecutive lines in the
         destination image.
pSrcDst  Pointer to the source and destination image ROI (for the in-
         place operation).
srcDstStep
Distance in bytes between starts of consecutive lines in the source and destination image buffer (for the in-place operation).

roiSize
Size of the source and destination ROI in pixels.

threshold
The threshold value to use for each pixel. In case of multi-channel data, an array of threshold values (one for each channel) is used.

value
The output value to be set for each pixel that satisfies the compare condition. In case of multi-channel data, an array of output values (one for each channel) is used.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function thresholds pixels in the source image pSrc using the specified level threshold. Pixel values in the source image are compared to the threshold value for "greater than".
If the result of the compare is true, the corresponding output pixel is set to the specified value. Otherwise, it is set to the source pixel value.

Return Values
ippStsNoErr
Indicates no error. Any other value indicates an error or a warning.
ippSts_Null_Ptr_Err
Indicates an error condition if one of the specified pointer is NULL.
ippStsSizeErr
Indicates an error condition if roiSize has a field with zero or negative value.
ippStsStepErr
Indicates an error condition if srcStep, dstStep, or srcDstStep has a zero or negative value.

Threshold_LTVal
Performs thresholding of pixel values in an image. Pixels that are less than threshold, are set to a specified value.

Syntax
Case 1: Not-in-place operation on one-channel data
IppStatus ippiThreshold_LTVal_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppSize roiSize, Ipp<datatype> threshold, Ipp<datatype> value);

Supported values for mod:
8u_C1R   16u_C1R   16s_C1R   32f_C1R
Case 2: Not-in-place operation on multi-channel data

IppStatus ippiThreshold_LTVal_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp<datatype> threshold[3], const Ipp<datatype> value[3]);

Supported values for mod:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>8u_C3R</td>
<td>16u_C3R</td>
<td>16s_C3R</td>
<td>32f_C3R</td>
</tr>
<tr>
<td>8u_AC4R</td>
<td>16u_AC4R</td>
<td>16s_AC4R</td>
<td>32f_AC4R</td>
</tr>
</tbody>
</table>

IppStatus ippiThreshold_LTVal_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp<datatype> threshold[4], const Ipp<datatype> value[4]);

Supported values for mod:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>8u_C4R</td>
<td>16u_C4R</td>
<td>16s_C4R</td>
<td>32f_C4R</td>
</tr>
</tbody>
</table>

Case 3: In-place operation on one-channel data

IppStatus ippiThreshold_LTVal_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp<datatype> threshold, Ipp<datatype> value);

Supported values for mod:

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<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>8u_C1IR</td>
<td>16u_C1IR</td>
<td>16s_C1IR</td>
<td>32f_C1IR</td>
</tr>
</tbody>
</table>

Case 4: In-place operation on multi-channel data

IppStatus ippiThreshold_LTVal_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, const Ipp<datatype> threshold[3], const Ipp<datatype> value[3]);

Supported values for mod:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>8u_C3IR</td>
<td>16u_C3IR</td>
<td>16s_C3IR</td>
<td>32f_C3IR</td>
</tr>
<tr>
<td>8u_AC4IR</td>
<td>16u_AC4IR</td>
<td>16s_AC4IR</td>
<td>32f_AC4IR</td>
</tr>
</tbody>
</table>

IppStatus ippiThreshold_LTVal_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, const Ipp<datatype> threshold[4], const Ipp<datatype> value[4]);

Supported values for mod:

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_C4IR</td>
<td>16u_C4IR</td>
<td>16s_C4IR</td>
<td>32f_C4IR</td>
</tr>
</tbody>
</table>

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

*pSrc*  
Pointer to the source image ROI.

*srcStep*  
Distance in bytes between starts of consecutive lines in the source image.

*pDst*  
Pointer to the destination image ROI.

*dstStep*  
Distance in bytes between starts of consecutive lines in the destination image.

*pSrcDst*  
Pointer to the source and destination image ROI (for the in-place operation).

*srcDstStep*  
Distance in bytes between starts of consecutive lines in the source and destination image buffer (for the in-place operation).

*roiSize*  
Size of the source and destination ROI in pixels.

*threshold*  
The threshold value to use for each pixel. In case of multi-channel data, an array of threshold values (one for each channel) is used.

*value*  
The output value to be set for each pixel that satisfies the compare condition. In case of multi-channel data, an array of output values (one for each channel) is used.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function thresholds pixels in the source image *pSrc* using the specified level *threshold*. Pixel values in the source image are compared to the *threshold* value for "less than". If the result of the compare is true, the corresponding output pixel is set to the specified *value*. Otherwise, it is set to the source pixel value.

Return Values

*ippStsNoErr*  
Indicates no error. Any other value indicates an error or a warning.

*ippStsNullPtrErr*  
Indicates an error condition if one of the specified pointer is NULL.

*ippStsSizeErr*  
Indicates an error condition if *roiSize* has a field with zero or negative value.

*ippStsStepErr*  
Indicates an error condition if *srcStep*, *dstStep*, or *srcDstStep* has a zero or negative value.

Threshold_LTValGTVal

Performs double thresholding of pixel values in an image buffer.
Syntax

Case 1: Not-in-place operation on one-channel data

IppStatus ippiThreshold_LTValGTVal_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, Ipp<datatype> thresholdLT, Ipp<datatype> valueLT, Ipp<datatype> thresholdGT, Ipp<datatype> valueGT);

Supported values for mod:

8u_C1R 16u_C1R 16s_C1R 32f_C1R

Case 2: Not-in-place operation on multi-channel data

IppStatus ippiThreshold_LTValGTVal_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp<datatype> thresholdLT[3], const Ipp<datatype> valueLT[3], const Ipp<datatype> thresholdGT[3], const Ipp<datatype> valueGT[3]);

Supported values for mod:

8u_C3R 16u_C3R 16s_C3R 32f_C3R
8u_AC4R 16u_AC4R 16s_AC4R 32f_AC4R

Case 3: In-place operation on one-channel data

IppStatus ippiThreshold_LTValGTVal_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp<datatype> thresholdLT, Ipp<datatype> valueLT, Ipp<datatype> thresholdGT, Ipp<datatype> valueGT);

Supported values for mod:

8u_C1IR 16u_C1IR 16s_C1IR 32f_C1IR

Case 4: In-place operation on multi-channel data

IppStatus ippiThreshold_LTValGTVal_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, const Ipp<datatype> thresholdLT[3], const Ipp<datatype> valueLT[3], const Ipp<datatype> thresholdGT[3], const Ipp<datatype> valueGT[3]);

Supported values for mod:

8u_C3IR 16u_C3IR 16s_C3IR 32f_C3IR
8u_AC4IR 16u_AC4IR 16s_AC4IR 32f_AC4IR

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **pSrcDst**: Pointer to the source and destination image ROI (for the in-place operation).
- **srcDstStep**: Distance in bytes between starts of consecutive lines in the source and destination image buffer (for the in-place operation).
- **roiSize**: Size of the source and destination ROI in pixels.
- **thresholdLT**: The lower threshold value to use for each pixel. In case of multi-channel data, an array of three lower threshold values (one for each color channel) is used.
- **valueLT**: The lower output value to be set for each pixel that is less than **thresholdLT**. In case of multi-channel data, an array of 3 lower output values (one for each color channel) is used.
- **thresholdGT**: The upper threshold value to use for each pixel. In case of multi-channel data, an array of three upper threshold values (one for each color channel) is used.
- **valueGT**: The upper output value to be set for each pixel that exceeds **thresholdGT**. In case of multi-channel data, an array of three upper output values (one for each color channel) is used.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function thresholds pixels in the source image **pSrc** using two specified levels **thresholdLT** and **thresholdGT**. Pixel values in the source image are compared to these levels. If the pixel value is less than **thresholdLT**, the corresponding output pixel is set to **valueLT**. If the pixel value is greater than **thresholdGT**, the output pixel is set to **valueGT**. Otherwise, it is set to the source pixel value. The value of **thresholdLT** should be less than or equal to **thresholdGT**.

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointer is NULL.
- **ippStsSizeErr**: Indicates an error condition if **roiSize** has a field with zero or negative value.
- **ippStsThresholdErr**: Indicates an error when **thresholdLT** is greater than **thresholdGT**.
- **ippStsStepErr**: Indicates an error condition if **srcStep**, **dstStep**, or **srcDstStep** has a zero or negative value.
Example

The code example below illustrates thresholding with two levels.

```c
IppStatus threshold( void ) {
    Ipp8u x[5*4];
    IppiSize roi = {5,4};
    int i;

    for( i=0; i<5*4; ++i ) x[i] = (Ipp8u)i;

    return ippiThreshold_LTValGTVal_8u_C1IR( x, 5, roi, 2,1,6,7 );
}
```

The destination image `x` contains:

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td>01</td>
<td>02</td>
<td>03</td>
<td>04</td>
</tr>
<tr>
<td>05</td>
<td>06</td>
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<td>07</td>
<td>07</td>
</tr>
</tbody>
</table>

**ComputeThreshold_Otsu**

**Computes the value of the Otsu threshold.**

**Syntax**

```c
IppStatus ippiComputeThreshold_Otsu_8u_C1R(const Ipp8u* pSrc, int srcStep, IppiSize roiSize, Ipp8u* pThreshold);
```

**Include Files**

ippi.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- `pSrc` Pointer to the source image ROI.
- `srcStep` Distance in bytes between starts of consecutive lines in the source image.
- `roiSize` Size of the image ROI in pixels.
- `pThreshold` Pointer to the Otsu threshold value.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function calculates the Otsu threshold ([Otsu79]) for the source image `pSrc` in accordance with the following formula:

$$
\min_T \left( \sum_{x=0}^{\text{roiSize.width}} \sum_{y=0}^{\text{roiSize.height}} \left[ \sigma(x,y \leq T) - \sigma(x,y > T) \right] \right)
$$

where $0 \leq x < \text{roiSize.width}$, $0 \leq y < \text{roiSize.height}$, and $T$ is the Otsu threshold.
where

\[
\sigma(p_{src}(x,y)) = \sqrt{\frac{\sum_{x,y \geq 0} (p_{src}(x,y) - mean)^2}{roiSize.height \cdot roiSize.width}}
\]

\[
mean = \frac{\sum_{x,y \geq 0} p_{src}(x,y)}{roiSize.height \cdot roiSize.width}
\]

The computed Otsu threshold can be used in the thresholding functions described above.

For example, the following figures shows how the Otsu threshold can be used for background/foreground selection. The figure a) below shows the initial image, the figure b) shows the histogram of the initial image with the red line indicating the computed Otsu threshold. The figure c) demonstrates the resulting image obtained by applying the function ippiThreshold_8u_C1R with a computed Otsu threshold value to the source image.

**Using Otsu Threshold for Background/Foreground Selection**

<table>
<thead>
<tr>
<th>number of pixels</th>
</tr>
</thead>
<tbody>
<tr>
<td>450</td>
</tr>
<tr>
<td>400</td>
</tr>
<tr>
<td>350</td>
</tr>
<tr>
<td>300</td>
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<tr>
<td>250</td>
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<tr>
<td>200</td>
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<tr>
<td>150</td>
</tr>
<tr>
<td>100</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

<figure>
<a>
![Initial Image](image1.jpg)
</a>
</figure>

<figure>
<a>
![Histogram](image2.jpg)
</a>
</figure>

<figure>
<a>
![Resulting Image](image3.jpg)
</a>
</figure>

**Return Values**

ippStsNoErr

 Indicates no error. Any other value indicates an error.
Indicates an error condition if one of the specified pointer is NULL.
Indicates an error condition if roiSize has a field with zero or negative value.
Indicates an error condition if srcStep is less than or equal to 0.

Compare Operations

This section describes functions that compare images. Each compare function writes its results to a one-channel Ipp8u output image. The output pixel is set to a non-zero value if the corresponding input pixel(s) satisfy the compare condition; otherwise, the output pixel is set to 0. You can compare either two images, or an image and a constant value, using the following compare conditions: "greater", "greater or equal", "less", "less or equal", "equal". Compare condition is specified as a function argument of IppCmpOp type (see Structures and Enumerators in Chapter 2 for more information). Images containing floating-point data can also be compared for being equal within a given tolerance eps.

For images with multi-channel data, the compare condition for a given pixel is true only when each color channel value of that pixel satisfies this condition.

Compare

Compares pixel values of two images using a specified compare operation.

Syntax

IppStatus ippiCompare_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp8u* pDst, int dstStep, IppiSize roiSize, IppCmpOp ippCmpOp);

Supported values for mod:

8u_C1R  16u_C1R  16s_C1R  32f_C1R
8u_C3R  16u_C3R  16s_C3R  32f_C3R
8u_C4R  16u_C4R  16s_C4R  32f_C4R

IppStatus ippiCompare_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp8u* pDst, int dstStep, IppiSize roiSize, IppCmpOp ippCmpOp);

Supported values for mod:

8u_AC4R  16u_AC4R  16s_AC4R  32f_AC4R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

- \( \text{pSrc1, pSrc2} \): Pointers to the source image ROIs.
- \( \text{src1Step, src2Step} \): Distances in bytes between starts of consecutive lines in the source images.
- \( \text{pDst} \): Pointer to the destination image ROI.
- \( \text{dstStep} \): Distance in bytes between starts of consecutive lines in the destination image.
- \( \text{roiSize} \): Size of the source and destination ROI in pixels.
- \( \text{ippCmpOp} \): Compare operation to be used for comparing the pixel values.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function compares the corresponding pixels of ROI in two source images \( \text{pSrc1, pSrc2} \) using the \( \text{ippCmpOp} \) compare operation, and writes the results to a one-channel Ipp8u image \( \text{pDst} \). If the result of the compare is true, the corresponding output pixel is set to an \( \text{IPP_MAX_8U} \) value; otherwise, it is set to 0.

Return Values

- \( \text{ippStsNoErr} \): Indicates no error. Any other value indicates an error or a warning.
- \( \text{ippStsNullPtrErr} \): Indicates an error condition if one of the specified pointer is NULL.
- \( \text{ippStsSizeErr} \): Indicates an error condition if \( \text{roiSize} \) has a field with zero or negative value.
- \( \text{ippStsStepErr} \): Indicates an error condition if \( \text{src1Step, src2Step, or dstStep} \) has a zero or negative value.

CompareC

Compares pixel values of a source image to a given value using a specified compare operation.

Syntax

Case 1: Operation on one-channel data

\[
\text{IppStatus ippiCompareC}_{<\text{mod}>}(\text{const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype> value, Ipp8u* pDst, int dstStep, IppiSize roiSize, IppCmpOp ippCmpOp});
\]

Supported values for \( \text{mod} \):

\[
\begin{align*}
8u\_C1R & \quad 16u\_C1R & \quad 16s\_C1R & \quad 32f\_C1R
\end{align*}
\]

Case 2: Operation on multi-channel data

\[
\text{IppStatus ippiCompareC}_{<\text{mod}>}(\text{const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[3], Ipp8u* pDst, int dstStep, IppiSize roiSize, IppCmpOp ippCmpOp});
\]

Supported values for \( \text{mod} \):

\[
\begin{align*}
8u\_C3R & \quad 16u\_C3R & \quad 16s\_C3R & \quad 32f\_C3R
\end{align*}
\]
IppStatusippiCompareC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[4], Ipp8u* pDst, int dstStep, IppiSize roiSize, IppCmpOp ippCmpOp);

Supported values for mod:

8u_C4R  16u_C4R  16s_C4R  32f_C4R

IppStatusippiCompareC_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp<datatype> value[3], Ipp8u* pDst, int dstStep, IppiSize roiSize, IppCmpOp ippCmpOp);

Supported values for mod:

8u_AC4R  16u_AC4R  16s_AC4R  32f_AC4R

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc
  Pointer to the source image ROI.

srcStep
  Distance in bytes between starts of consecutive lines in the source image.

value
  The value to compare each pixel to. In case of multi-channel data, an array of separate values (one for each channel).

pDst
  Pointer to the destination image ROI.

dstStep
  Distance in bytes between starts of consecutive lines in the destination image.

roiSize
  Size of the source and destination ROI in pixels.

ippCmpOp
  Compare operation to be used for comparing the pixel values.

Description

This function operates with ROI (Regions of Interest in Intel IPP).

This function compares pixels of each channel of the source image ROI pSrc to a given value specified for each channel using the ippCmpOp compare operation, and writes the results to a one-channel ipp8u image pDst. If the result of the compare is true, that is, all pixels of all channels meet the specified condition, then the corresponding output pixel is set to an IPP_MAX_8U value; otherwise, it is set to 0.

Return Values

ippiStsNoErr
  Indicates no error. Any other value indicates an error or a warning.

ippiStsNullPtrErr
  Indicates an error condition if one of the specified pointer is NULL.

ippiStsSizeErr
  Indicates an error condition if roiSize has a field with zero or negative value.
Indicates an error condition if srcStep or dstStep has a zero or negative value.

Example

The code example below shows how to use the comparison function and create a mask image:

```c
IppStatus compare ( void ) {
    Ipp8u x[5*4], y[5*4];
    IppiSize roi = {5,4};
    int i;
    for( i=0; i<5*4; ++i ) x[i] = (Ipp8u)i;
    return ippiCompareC_8u_C1R ( x, 5, 7, y, 5, roi, ippCmpGreater );
}
```

The mask image y contains:

```
00 00 00 00 00
00 00 00 FF FF
FF FF FF FF FF
FF FF FF FF FF
```

**CompareEqualEps**

Compares two images with floating-point data, testing whether pixel values are equal within a certain tolerance eps.

**Syntax**

```c
IppStatus ippiCompareEqualEps_<mod>(const Ipp32f* pSrc1, int src1Step, const Ipp32f* pSrc2, int src2Step, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp32f eps);
```

Supported values for mod:

- 32f_C1R
- 32f_C3R
- 32f_C4R

```c
IppStatus ippiCompareEqualEps_32f_AC4R(const Ipp32f* pSrc1, int src1Step, const Ipp32f* pSrc2, int src2Step, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp32f eps);
```

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **pSrc1, pSrc2**  
  Pointers to the source image ROIs.
- **src1Step, src2Step**  
  Distances in bytes between starts of consecutive lines in the source images.
pDst

Pointer to the destination image ROI.

dstStep

Distance in bytes between starts of consecutive lines in the destination image.

roiSize

Size of the source and destination ROI in pixels.

eps

The tolerance value.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function tests if the corresponding pixels of ROI in two source images pSrc1, pSrc2 are equal within the tolerance eps, and writes the results to a one-channel Ipp8u image pDst. If the absolute value of difference of the pixel values in pSrc1 and pSrc2 is less than or equal to eps, then the corresponding pixel in pDst is set to an IPP_MAX_8U value; otherwise the pixel in pDst is set to 0. For multi-channel images, the differences for all color channel values of a pixel must be within the eps tolerance for the compare condition to be true.

This function processes images with floating-point data only.

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr

Indicates an error condition if one of the specified pointer is NULL.

ippStsSizeErr

Indicates an error condition if roiSize has a field with zero or negative value.

ippStsStepErr

Indicates an error condition if src1Step, src2Step, or dstStep has a zero or negative value.

ippStsEpsValErr

Indicates an error condition if eps has a negative value.

CompareEqualEpsC

Tests whether floating-point pixel values of an image are equal to a given value within a certain tolerance eps.

Syntax

Case 1: Operation on one-channel data

IppStatus ippiCompareEqualEpsC_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f value, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp32f eps);

Case 2: Operation on multi-channel data

IppStatus ippiCompareEqualEpsC_32f_C3R(const Ipp32f* pSrc, int srcStep, const Ipp32f value[3], Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp32f eps);

IppStatus ippiCompareEqualEpsC_32f_C4R(const Ipp32f* pSrc, int srcStep, const Ipp32f value[4], Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp32f eps);

IppStatus ippiCompareEqualEpsC_32f_AC4R(const Ipp32f* pSrc, int srcStep, const Ipp32f value[3], Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp32f eps);
Include Files
ippi.h

Domain Dependencies
Headers: ippi.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
- **pSrc**
  Pointer to the source image ROI.
- **srcStep**
  Distance in bytes between starts of consecutive lines in the source image.
- **value**
  The value to compare each pixel to. In case of multi-channel data, an array of separate values (one for each channel).
- **pDst**
  Pointer to the destination image ROI.
- **dstStep**
  Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**
  Size of the source and destination ROI in pixels.
- **eps**
  The tolerance value.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function tests if pixel values of the source image ROI `pSrc` are equal to a given constant `value` within the tolerance `eps`, and writes the results to a one-channel Ipp8u image `pDst`. If the absolute value of difference between the pixel value in `pSrc` and `value` is less than or equal to `eps`, then the corresponding pixel in `pDst` is set to an IPP_MAX_8U value; otherwise the pixel in `pDst` is set to 0. For multi-channel images, the differences between all color channel values of a pixel and the respective components of `value` must be within the tolerance `eps` for the compare condition to be true.

This function processes images with floating-point data only.

Return Values
- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**
  Indicates an error condition if one of the specified pointer is NULL.
- **ippStsSizeErr**
  Indicates an error condition if `roiSize` has a field with a zero or negative value.
- **ippStsStepErr**
  Indicates an error condition if `srcStep` or `dstStep` has a zero or negative value.
- **ippStsEpsValErr**
  Indicates an error condition if `eps` has a negative value.
This chapter describes the Intel® IPP image processing functions that perform morphological operations on images.

Generally, the erosion and dilation smooth the boundaries of objects without significantly changing their area. Opening and closing smooth thin projections or gaps. Morphological operations use a structuring element (SE) that is a user-defined rectangular mask, or for some functions - symmetric 3x3 mask.

In a more general sense, morphological operations involve an image \( A \) called the object of interest and a kernel element \( B \) called the structuring element. The image and structuring element could be in any number of dimensions, but the most common use is with a 2D binary image, or with a 3D gray scale image. The element \( B \) is most often a square or a circle, but it could be of any shape. Just like in convolution, \( B \) is a kernel or template with an anchor point. Figure "Dilation and Erosion of \( A \) by \( B \)" shows dilation and erosion of object \( A \) by \( B \). In the figure, \( B \) is rectangular with an anchor point at upper left shown as a dark square.

**Dilation and Erosion of \( A \) by \( B \)**

Let \( B_t \) is the SE with pixel \( t \) in the anchor position, \( B \) is transpose of the SE.

Dilation of binary image \( A \) \( \{A(t) = 1, \ t \in A; \ 0 \text{ - otherwise}\} \) by binary SE \( B \) is

\[
A \oplus B = \{t : B_t \cap A \neq 0\}
\]

It means that every pixel is in the set, if the intersection is not null. That is, a pixel under the anchor point of \( B \) is marked "on", if at least one pixel of \( B \) is inside of \( A \).

Erosion of the binary image \( A \) by the binary SE \( B \) is

\[
A \ominus B = \{t : B_t \subseteq A\}
\]

That is, a pixel under the anchor of \( B \) is marked "on", if \( B \) is entirely within \( A \).

Generalization of dilation and erosion for the gray-scale image \( A \) and the binary SE \( B \) is

\[
A \oplus B = \left\{ \max_{u \in B_t \cap A} A(u) \right\}, \quad A \ominus B = \left\{ \min_{u \in B_t \cap A} A(u) \right\}
\]
Generalization of dilation and erosion for the gray-scale image $A$ and the gray-scale SE $B$ is

$$A \oplus B = \left\{ \max_{u \in B_k \cap A} \left( A(u) + B(u - t) \right) \right\}, \quad A \ominus B = \left\{ \min_{u \in B_k \cap A} \left( A(u) + B(u - t) \right) \right\}$$

Opening operation of $A$ by $B$ is $A \circ B = (A \ominus B) \oplus \overline{B}$.

Closing operation of $A$ by $B$ is $A \bullet B = (A \oplus B) \ominus \overline{B}$.

Top-hat operation of $A$ by $B$ is $A - A \ominus B$.

Black-hat operation of $A$ by $B$ is $A \bullet B - A$.

Black-hat operation of $A$ by $B$ is $A \ominus B - A \ominus B$.

Morphological reconstruction [Vincent93] $\rho_A(C)$ of an image $A$ from the image $C$, $A(t) \geq C(t)$ $\forall t$ by dilation with the mask $B$ is an image

$$C_k : k = \min_i C_i \equiv C_{i-1}, \quad C_0 = C, \quad C_{i+1}(t) = \min\{ (C_i \oplus B)(t), A(t) \}$$

Morphological reconstruction $\rho_A(C)$ of an image $A$ from the image $C$, $A(t) \leq C(t)$ $\forall t$ by erosion with the mask $B$ is an image

$$C_k : k = \max_i C_i \equiv C_{i-1}, \quad C_0 = C, \quad C_{i+1}(t) = \max\{ (C_i \ominus B)(t), A(t) \}$$

Figure "Morphological Operations Performed by Intel IPP" presents the results of different morphological operations applied to the initial image. In these operations, the SE is a matrix of 3x3 size with the following values:

$$\begin{bmatrix} -8 & 0 & -8 \\ 0 & 8 & 0 \\ -8 & 0 & -8 \end{bmatrix}$$

for common and advanced morphology, and

$$\begin{bmatrix} -5 & 0 & -5 \\ 0 & 5 & 0 \\ -5 & 0 & -5 \end{bmatrix}$$

for gray morphology.
The anchor cell is in the center cell (1,1) of the matrix.

**Morphological Operations Performed by Intel IPP**
Flat Structuring Elements for Grayscale Image

Erosion and dilation can be done in 3D space, that is, with gray levels. 3D structuring elements can be used, but the simplest and the best way is to use a flat structuring element $B$. Figure "1D Cross Section of Dilation and Erosion of A by B" is a 1D cross section of dilation and erosion of a grayscale image $A$ by a flat structuring element $B$. In the figure, $B$ has an anchor slightly to the right of the center as shown by the dark mark on $B$.

1D Cross Section of Dilation and Erosion of A by B

In Figure "1D Cross Section of Dilation and Erosion of A by B" above, dilation is mathematically

$$\sup_{y \in B} A$$

and erosion is

$$\inf_{y \in B} A$$

Dilate3x3

Performs dilation of an image using a 3x3 mask.
Syntax

IppStatusippiDilate3x3_64f_C1R(const Ipp64f* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc Pointer to the source image ROI.
srcStep Distance in bytes between starts of consecutive lines in the source image.
pDst Pointer to the destination image ROI.
dstStep Distance in bytes between starts of consecutive lines in the destination image.
roiSize Size of the source and destination ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function performs dilation of a rectangular ROI area inside a 2D image using a symmetric 3x3 mask.
Source and destination images can be of different sizes, but the ROI size is the same for both images. The output pixel is set to the maximum of the corresponding input pixel and its eight neighboring pixels.

Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error condition if pSrc or pDst is NULL.
ippStsSizeErr Indicates an error condition if roiSize has a field with zero or negative value.
ippStsStepErr Indicates an error condition if srcStep or dstStep has a zero or negative value.

Dilate

Performs dilation of an image using a specified mask.

Syntax

IppStatusippiDilate_8u_C1R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[1], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);
IppStatus ippiDilate_8u_C3R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[3], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiDilate_8u_C4R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[4], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiDilate_32f_C3R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[3], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiDilate_32f_C1R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[1], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiDilate_32f_C4R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[4], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiDilate_16u_C1R_L(const Ipp16u* pSrc, IppSizeL srcStep, int srcBitOffset, Ipp16u* pDst, IppSizeL dstStep, int dstBitOffset, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[1], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiDilate_16s_C1R_L(const Ipp16s* pSrc, IppSizeL srcStep, int srcBitOffset, Ipp16s* pDst, IppSizeL dstStep, int dstBitOffset, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[1], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiDilate_1u_C1R_L(const Ipp8u* pSrc, IppSizeL srcStep, int srcBitOffset, Ipp8u* pDst, IppSizeL dstStep, int dstBitOffset, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[1], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

Include Files

ippcv_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc
srcStep
pDst
dstStep
roiSize
borderType

Pointer to the source image ROI.

Distance, in bytes, between the starting points of consecutive lines in the source image.

Pointer to the destination image ROI.

Distance, in bytes, between the starting points of consecutive lines in the destination image.

Size of the source and destination ROI, in pixels.

Type of the border; supported values:

ippBorderDefault The border is set to ippBorderConst with
borderValue= MIN_VALUE, where
MIN_VALUE=IPP_MIN_8U/16U/16S/32F/1U
<table>
<thead>
<tr>
<th>Macro</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippBorderRepl</td>
<td>Border is replicated from the edge pixels.</td>
</tr>
<tr>
<td>ippBorderMirror</td>
<td>Border pixels are mirrored from the source image boundary pixels.</td>
</tr>
<tr>
<td>ippBorderConst</td>
<td>Values of all border pixels are set to a constant.</td>
</tr>
<tr>
<td>ippBorderInMem</td>
<td>Border is obtained from the source image pixels in memory.</td>
</tr>
</tbody>
</table>

Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, or ippBorderMirror values and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.

- **borderValue**: Pointer to the vector of values for the constant border type.
- **srcBitOffset**: Offset in the first byte of the source image row.
- **dstBitOffset**: Offset in the first byte of the destination image row.
- **pMorphSpec**: Pointer to the morphology specification structure.
- **pBuffer**: Pointer to the external work buffer.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function performs dilation of a rectangular ROI area inside a one-, three-, or four-channel 2D image using a specified mask `pMask` of size `maskSize` and alignment `anchor`.

Source and destination images can be of different sizes, but the ROI size is the same for both images. The output pixel is set to the maximum of the corresponding input pixel and its neighboring pixels that are picked out by the nonzero mask values. In the four-channel image the alpha channel is not processed.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if `pSrc` or `pDst` is NULL.
- **ippStsSizeErr**: Indicates an error condition if `roiSize` has a field with a zero or negative value.
- **ippStsStepErr**: Indicates an error condition if `srcStep` or `dstStep` has a zero or negative value.
- **ippStsNotEvenStepErr**: Indicates an error condition if `srcStep` or `dstStep` has a not pixel multiple value.
- **ippStsBadArgErr**: Indicates an error condition if `borderType` has an incorrect value.

**DilateBorder**

*Performs dilation of an image.*
Syntax

IppStatus ippiDilateBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, Ipp<datatype> borderValue, const IppiMorphState* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C1R 16u_C1R 16s_C1R 32f_C1R

IppStatus ippiDilateBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, const Ipp<datatype> borderValue[3], const IppiMorphState* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C3R 32f_C3R

IppStatus ippiDilateBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, const Ipp<datatype> borderValue[4], const IppiMorphState* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C4R 32f_C4R

IppStatus ippiDilateBorder_1u_C1R(const Ipp8u* pSrc, int srcStep, int srcBitOffset, Ipp8u* pDst, int dstStep, int dstBitOffset, IppiSize roiSize, IppiBorderType borderType, Ipp8u borderValue, const IppiMorphState* pSpec, Ipp8u* pBuffer);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc
srcStep
srcBitOffset
pDst
dstStep
dstBitOffset
roiSize
borderType

Pointer to the source image ROI.
Distance in bytes between the starting points of consecutive lines in the source image.
Offset, in bits, from the first byte of the source image (for 1u_C1R flavor).

Pointer to the destination image ROI.
Distance, in bytes, between the starting points of consecutive lines in the destination image.
Offset, in bits, from the first byte of the destination image (for 1u_C1R flavor).

Size of the source and destination image ROI.
Type of border. Possible values are:
ippBorderRepl  Border is replicated from the edge pixels.
ippBorderInMem Border is obtained from the source image pixels in memory.

borderValue Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

pSpec Pointer to the specification structure.

pBuffer Pointer to the external buffer required for dilation operations.

Description
This function operates with ROI.
This function expands a rectangular ROI area inside a one-channel two-dimensional image using a mask specified in the specification structure pSpec. Before using this function, you need to initialize the structure using the MorphologyBorderInit function.
The output pixel is set to the maximum of the corresponding input pixel and its neighboring pixels that are picked out by the nonzero mask values.

Return Values
ippStsNoErr Indicates no error.
ippStsNullPtrErr Indicates an error when one of the specified pointers is NULL.
ippStsSizeErr Indicates an error when:
• roiSize has a field with a zero or negative value
• roiSize.width is more than the maximum ROI roiWidth passed to the initialization function
ippStsStepErr Indicates an error when srcStep or dstStep is less than roiSize.width*<pixelSize>.
ippStsNotEvenStepErr Indicates an error when one of the step values for 16-bit integer images is not divisible by 2.
ippStsBorderErr Indicates an error when borderType has an illegal value.
ippStsInplaceModeNotSupportedErr Indicates an error when the pSrc pointer is equal to the pDst pointer.

Example
The code example below demonstrates how to use the ippiMorphologyBorderGetSize_16u_C1R, ippiMorphologyBorderInit_16u_C1R, and ippiDilateBorder_16u_C1R functions to perform dilation of the source image.

IppStatus func_MorfDilateBorder()
{
    IppiMorphState* pSpec = NULL;
    Ipp8u* pBuffer = NULL;
    IppiSize roiSize = {5, 5};
    Ipp8u pMask[3*3] = {1, 1, 1,
                         1, 0, 1,
                         1, 1, 1};
    IppiSize maskSize = {3, 3};
Ipp16u pSrc[5*5] = { 1, 2, 4, 1, 2,
5, 1, 2, 1, 2,
1, 2, 1, 2, 1,
1, 2, 1, 2, 1,
2, 1, 5, 1, 2};

Ipp16u pDst[5*5];
int srcStep = 5*sizeof(Ipp16u);
int dstStep = 5*sizeof(Ipp16u);
int dstSize = 5;
IppStatus status = ippStsNoErr;
int specSize = 0, bufferSize = 0;
IppiBorderType borderType= ippBorderRepl;
Ipp16u borderValue = 0;

status =ippiMorphologyBorderGetSize_16u_C1R( roiSize, maskSize, &specSize, &bufferSize );
if (status != ippStsNoErr) return status;

pSpec = (IppiMorphState*)ippsMalloc_8u(specSize);
pBuffer = (Ipp8u*)ippsMalloc_8u(bufferSize);

status =ippiMorphologyBorderInit_16u_C1R( roiSize, pMask, maskSize, pSpec, pBuffer );
if (status != ippStsNoErr) {
    ippsFree(pBuffer);
    ippsFree(pSpec);
    return status;
}

status =ippiDilateBorder_16u_C1R( pSrc, srcStep, pDst, dstStep, roiSize, borderType,
borderValue, pSpec, pBuffer);

ippsFree(pBuffer);
ippsFree(pSpec);
return status;

The result is as follows:

pDst->
5 5 4 4 2
5 5 4 4 2
5 5 2 2 2
2 5 5 5 2
2 5 5 5 2

See Also
Regions of Interest in Intel IPP
User-defined Border Types
MorphologyBorderInit  Initializes the morphology specification structure for erosion or dilation operations.

DilateGetBufferSize

Computes the size of the working buffer for the Dilate function.
Syntax

IppStatus ippiDilateGetBufferSize_L(IppiSizeL roiSize, IppiSizeL maskSize, IppDataType dataType, int numChannels, IppSizeL* pBufferSize);

Include Files

ippcv_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

roiSize, maskSize, dataType, numChannels, pBufferSize

Description

This function computes the size of the working buffer required for the ippiDilate functions with the _L suffix.

Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error when one of the pointers is NULL.
ippStsSizeErr Width of the image, or width or height of the structuring element is less than, or equal to zero.

DilateGetSpecSize

Computes the size of the internal state or specification structure for the Dilate function.

Syntax

IppStatus ippiDilateGetSpecSize_L(IppiSizeL roiSize, IppiSizeL maskSize, IppSizeL* pSpecSize);

Include Files

ippcv_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Parameters

roiSize
Size of the source and destination image ROI, in pixels.

maskSize
Size of the structuring element.

pSpecSize
Pointer to the size of the specification structure.

Description

This function computes the size of the specification structure required for the ippiDilate functions with the _L suffix.

Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr
Indicates an error when one of the pointers is NULL.

ippStsSizeErr
Width of the image, or width or height of the structuring element is less than, or equal to zero.

DilateInit

Initializes the internal state or specification structure for the Dilate function.

Syntax

IppStatus ippiDilateInit_L(IppSizeL roiSize, const Ipp8u* pMask, IppSizeL maskSize, IppiMorphStateL* pMorphSpec);

Include Files

ippcv_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

roiSize
Size of the source and destination image ROI, in pixels.

pMask
Pointer to the structuring element (mask).

maskSize
Size of the structuring element.

pMorphSpec
Pointer to the morphology specification structure.

Description

This function initializes the internal state or specification structure for the ippiDilate functions with the _L suffix.

Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error or a warning.
**Erode3x3**

*Performs erosion of an image using a 3x3 mask.*

**Syntax**

```
IppStatus ippiErode3x3_64f_C1R(const Ipp64f* pSrc, int srcStep, Ipp64f* pDst, int dstStep, IppiSize roiSize);
```

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- `pSrc`: Pointer to the source image ROI.
- `srcStep`: Distance in bytes between starts of consecutive lines in the source image.
- `pDst`: Pointer to the destination image ROI.
- `dstStep`: Distance in bytes between starts of consecutive lines in the destination image.
- `roiSize`: Size of the source and destination ROI in pixels.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function performs erosion of a rectangular ROI area inside a 2D image using a symmetric 3x3 mask. Source and destination images can have different size, but the ROI size is the same for both images. The output pixel is set to the minimum of the corresponding input pixel and its 8 neighboring pixels.

**Return Values**

- `ippStsNoErr`: Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr`: Indicates an error condition if `pSrc` or `pDst` is NULL.
- `ippStsSizeErr`: Indicates an error condition if `roiSize` has a field with a zero or negative value.
- `ippStsStepErr`: Indicates an error condition if `srcStep` or `dstStep` has a zero or negative value.
Erode

Performs erosion of an image using a specified mask.

Syntax

IppStatus ippiErode_8u_C1R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[1], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiErode_8u_C3R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[3], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiErode_8u_C4R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[4], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiErode_32f_C3R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[3], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiErode_32f_C1R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[1], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiErode_32f_C4R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[4], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiErode_16u_C1R_L(const Ipp16u* pSrc, IppSizeL srcStep, Ipp16u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp16u borderValue[1], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiErode_16s_C1R_L(const Ipp16s* pSrc, IppSizeL srcStep, Ipp16s* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp16s borderValue[1], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiErode_1u_C1R_L(const Ipp8u* pSrc, IppSizeL srcStep, int srcBitOffset, Ipp8u* pDst, IppSizeL dstStep, int dstBitOffset, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[1], const IppiMorphStateL* pMorphSpec, Ipp8u* pBuffer);

Include Files

ippcv_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc  
Pointer to the source image ROI.

srcStep  
Distance, in bytes, between the starting points of consecutive lines in the source image.

dDst  
Pointer to the destination image ROI.
**dstStep**

Distance, in bytes, between the starting points of consecutive lines in the destination image.

**roiSize**

Size of the source and destination ROI, in pixels.

**borderType**

Type of the border; supported values:

- **ippBorderDefault**
  - The border is set to `ippBorderConst` with `borderValue` set to `MAX_VALUE`, where `MAX_VALUE` is defined as `IPP_MAX_8U/16U/16S/32F/1U`.
- **ippBorderRepl**
  - Border is replicated from the edge pixels.
- **ippBorderMirror**
  - Border pixels are mirrored from the source image boundary pixels.
- **ippBorderConst**
  - Values of all border pixels are set to a constant.
- **ippBorderInMem**
  - Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation `OR` between any of the `ippBorderRepl`, `ippBorderConst`, or `ippBorderMirror` values and the `ippBorderInMemTop`, `ippBorderInMemBottom`, `ippBorderInMemLeft`, `ippBorderInMemRight` values.

**borderValue**

Pointer to the vector of values for the constant border type.

**srcBitOffset**

Offset in the first byte of the source image row.

**dstBitOffset**

Offset in the first byte of the destination image row.

**pMorphSpec**

Pointer to the morphology specification structure.

**pBuffer**

Pointer to the external work buffer.

---

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function performs erosion of a rectangular ROI area inside a one-, three-, or four-channel 2D image using a specified mask `pMask` of size `maskSize` and alignment `anchor`.

Source and destination images can be of different sizes, but the ROI size is the same for both images (`dstRoiSize`). The output pixel is set to the minimum of the corresponding input pixel and its neighboring pixels that are picked out by the non-zero mask values. In the four-channel image the alpha channel is not processed.

**Return Values**

- **ippStsNoErr**
  - Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**
  - Indicates an error condition if `pSrc` or `pDst` is `NULL`.
- **ippStsSizeErr**
  - Indicates an error condition if `roiSize` has a field with a zero or negative value.
- **ippStsStepErr**
  - Indicates an error condition if `srcStep` or `dstStep` has a zero or negative value.
Indicates an error condition if srcStep or dstStep has a non-pixel multiple value.

Indicates an error condition if borderType has an incorrect value.

ErodeBorder

Performs erosion of an image.

Syntax

IppStatus ippiErodeBorder_\langle mod\rangle (const Ipp\langle datatype\rangle* pSrc, int srcStep, Ipp\langle datatype\rangle* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, Ipp\langle datatype\rangle borderValue, const IppiMorphState* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u_C1R 16u_C1R 16s_C1R 32f_C1R

IppStatus ippiErodeBorder_\langle mod\rangle (const Ipp\langle datatype\rangle* pSrc, int srcStep, Ipp\langle datatype\rangle* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, const Ipp\langle datatype\rangle borderValue[3], const IppiMorphState* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u_C3R 32f_C3R

IppStatus ippiErodeBorder_\langle mod\rangle (const Ipp\langle datatype\rangle* pSrc, int srcStep, Ipp\langle datatype\rangle* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, const Ipp\langle datatype\rangle borderValue[4], const IppiMorphState* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u_C4R 32f_C4R

IppStatus ippiErodeBorder_1u_C1R(const Ipp8u* pSrc, int srcStep, int srcBitOffset, Ipp8u* pDst, int dstStep, int dstBitOffset, IppiSize roiSize, IppiBorderType borderType, Ipp8u borderValue, const IppiMorphState* pSpec, Ipp8u* pBuffer);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc
srcStep
srcBitOffset

Pointer to the source image ROI.

Distance, in bytes, between the starting points of consecutive lines in the source image.

Offset, in bits, from the first byte of the source image (for 1u_C1R flavor).
**pDst**
Pointer to the destination image ROI.

**dstStep**
Distance, in bytes, between the starting points of consecutive lines in the destination image.

**dstBitOffset**
Offset, in bits, from the first byte of the destination image (for 1u_C1R flavor).

**roiSize**
Size of the source and destination image ROI.

**borderType**
Type of border. Possible values are:
- ippBorderRepl Border is replicated from the edge pixels.
- ippBorderInMem Border is obtained from the source image pixels in memory.

**borderValue**
Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

**pSpec**
Pointer to the specification structure.

**pBuffer**
Pointer to the external buffer required for erosion operations.

**Description**
This function operates with ROI.

This function performs erosion of a rectangular ROI area inside a one-channel 2D image using a mask specified in the specification structure *pSpec*. Before using this function, you need to initialize the structure using the MorphologyBorderInit function.

The output pixel is set to the maximum of the corresponding input pixel and its neighboring pixels that are picked out by the nonzero mask values.

**Return Values**
- ippStsNoErr Indicates no error.
- ippStsNullPtrErr Indicates an error when one of the specified pointers is NULL.
- ippStsSizeErr Indicates an error when:
  - roiSize has a field with a zero or negative value
  - roiSize.width is more than the maximum ROI roiWidth passed to the initialization function
  - srcBitOffset or dstBitOffset is less than zero
- ippStsStepErr Indicates an error when srcStep or dstStep is less than roiSize.width* pixelSize.
- ippStsNotEvenStepErr Indicates an error when one of the step values for 16-bit integer images is not divisible by 2.
- ippStsBorderErr Indicates an error when borderType has an illegal value.
- ippStsInplaceModeNotSupportedErr Indicates an error when the pSrc pointer is equal to the pDst pointer.

**See Also**
Regions of Interest in Intel IPP
User-defined Border Types
MorphologyBorderInit  Initializes the morphology specification structure for erosion or dilation operations.

ErodeGetBufferSize

*Computes the size of the working buffer for the Erode function.*

**Syntax**

```c
IppStatus ippiErodeGetBufferSize_L(IppiSizeL roiSize, IppiSizeL maskSize, IppDataType datatype, int numChannels, IppSizeL* pBufferSize);
```

**Include Files**

ippcv_l.h

**Domain Dependencies**

*Headers: ippcore.h, ippvm.h, ipps.h, ippi.h*

*Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib*

**Parameters**

- **roiSize**: Size of the source and destination image ROI, in pixels.
- **maskSize**: Size of the structuring element.
- **dataType**: Data type for the morphological function.
- **numChannels**: Number of channels in the image.
- **pBufferSize**: Pointer to the buffer size value for the morphological initialization function.

**Description**

This function computes the size of the working buffer required for the ippiErode functions with the _L suffix.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when one of the pointers is NULL.
- **ippStsSizeErr**: Width of the image, or width or height of the structuring element is less than, or equal to zero.

ErodeGetSpecSize

*Computes the size of the internal state or specification structure for the Erode function.*

**Syntax**

```c
IppStatus ippiErodeGetSpecSize_L(IppiSizeL roiSize, IppiSizeL maskSize, IppSizeL* pSpecSize);
```
Include Files
ippcv_l.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
roiSize  Size of the source and destination image ROI, in pixels.
maskSize Size of the structuring element.
pSpecSize Pointer to the size of the specification structure.

Description
This function computes the size of the specification structure required for the ippiErode functions with the _L suffix.

Return Values
ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error when one of the pointers is NULL.
ippStsSizeErr Width of the image, or width or height of the structuring element is less than, or equal to zero.

ErodeInit

Initializes the internal state or specification structure for the Erode function.

Syntax
IppStatus ippiErodeInit_L(IppiSizeL roiSize, const Ipp8u* pMask, IppiSizeL maskSize, IppiMorphStateL* pMorphSpec);

Include Files
ippcv_l.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
roiSize  Size of the source and destination image ROI, in pixels.
pMask Pointer to the structuring element (mask).
maskSize Size of the structuring element.
pMorphSpec Pointer to the morphology specification structure.
**Description**

This function initializes the internal state or specification structure for the `ippiErode` functions with the `_L` suffix.

**Return Values**

- `ippStsNoErr` Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr` Indicates an error when one of the pointers is `NULL`.
- `ippStsSizeErr` Width of the image, or width or height of the structuring element is less than, or equal to zero.
- `ippStsAnchorErr` Anchor point is outside the structuring element.

**GrayDilateBorder**

*Performs gray-kernel dilation of an image.*

**Syntax**

```c
IppStatus ippiGrayDilateBorder_8u_C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, IppiBorderType border, IppiMorphGrayState_8u* pState);
IppStatus ippiGrayDilateBorder_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiBorderType border, IppiMorphGrayState_32f* pState);
```

**Include Files**

`ippcv.h`

**Domain Dependencies**

**Headers:** `ippcore.h`, `ippvm.h`, `ipps.h`, `ippi.h`

**Libraries:** `ippcore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`

**Parameters**

- `pSrc` Pointer to the source image ROI.
- `srcStep` Distance in bytes between starts of consecutive lines in the source image.
- `pDst` Pointer to the destination image ROI.
- `dstStep` Distance in bytes between starts of consecutive lines in the destination image.
- `roiSize` Size of the source and destination image ROI.
- `border` Type of border; the possible value is `ippBorderRepl`, which means that a replicated border is used.
- `pState` Pointer to the morphology state structure.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).
This function performs gray-kernel dilation of a rectangular ROI area inside a one-channel 2D image using a specified in the gray-kernel morphology state structure pState mask and the anchor cell. This structure must be initialized by MorphGrayInit beforehand.

**NOTE**
The structure can be used to process images with ROI that does not exceed the specified maximum width and height roiSize.

## Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if roiSize has a field with a zero or negative value, or if one of ROI width or height is greater than corresponding size of ROI passed to the initialization functions.
- **ippStsStepErr**: Indicates an error condition if srcStep or dstStep is less than roiSize.width * <pixelSize>.
- **ippStsNotEvenStepErr**: Indicates an error condition if one of the step values is not divisible by 4 for floating-point images.
- **ippStsBorderErr**: Indicates an error condition if border has an illegal value.

## GrayErodeBorder

**Performs gray-kernel erosion of an image.**

### Syntax

```c
IppStatus ippiGrayErodeBorder_8u_C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, IppiBorderType border, IppiMorphGrayState_8u* pState);
```

### Include Files

```
ippcv.h
```

### Domain Dependencies

**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

### Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
dstStep
Distance in bytes between starts of consecutive lines in the destination image.
roiSize
Size of the source and destination image ROI.
border
Type of border; the possible value is ippBorderRepl, which means that a replicated border is used.
pState
Pointer to the morphology state structure.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function performs gray-kernel erosion of a rectangular ROI area inside a one-channel 2D image using a specified in the gray-kernel morphology state structure pState mask and the anchor cell. This structure must be initialized by MorphGrayInit beforehand.

NOTE
The structure can be used to process images with ROI that does not exceed the specified maximum width and height roiSize.

Return Values
ippStsNoErr
Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr
Indicates an error condition if one of the specified pointers is NULL.
ippStsSizeErr
Indicates an error condition if roiSize has a field with a zero or negative value, or if one of ROI width or height is greater than corresponding size of ROI passed to the initialization functions.
ippStsStepErr
Indicates an error condition if srcStep or dstStep is less than roiSize.width * <pixelSize>.
ippStsNotEvenStepErr
Indicates an error condition if one of the step values is not divisible by 4 for floating-point images.
ippStsBorderErr
Indicates an error condition if border has an illegal value.

MorphAdvInit
Initializes the specification structure for advanced morphological operations.

Syntax
IppStatus ippiMorphAdvInit_<mod>(IppiSize roiSize, const Ipp8u* pMask, IppiSize maskSize, IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Supported values for mod:
1u_C1R 8u_C1R 16u_C1R 16s_C1R 32f_C1R
8u_C3R 32f_C3R
8u_C4R 32f_C4R
Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSpec
Pointer to the specification structure.

roiSize
Maximal size of the image ROI (in pixels) that can be processed
using the allocated structure.

pMask
Pointer to the mask.

maskSize
Size of the mask in pixels.

pBuffer
Pointer to the external buffer for advanced morphological
operations.

Description
This function operates with ROI.
This function initializes the specification structure pSpec in the external buffer. This structure is used by the
MorphOpenBorder and MorphCloseBorder functions that perform open and close morphological operations.
All advanced morphological operations are performed on the source image pixels corresponding to non-zero
values of the structuring element (mask) pMask.

NOTE
This function required that the image ROI does not exceed the maximum width and height
roiSize specified by the initialization functions.

For an example on how to use this function, see the code example provided with the MorphCloseBorder
function description.

Return Values
ippStsNoErr
Indicates no error.

ippStsNullPtrErr
Indicates an error when one of the specified pointers is NULL.

ippStsSizeErr
Indicates an error when maskSize has a field with a zero or
negative value, or if roiWidth is less than 1.

ippStsAnchorErr
Indicates an error when anchor is outside the mask.

See Also
Regions of Interest in Intel IPP
MorphAdvGetSize Computes the size of the specification structure for advanced morphological
operations.
MorphOpenBorder Opens an image.
MorphCloseBorder Closes an image.
MorphTophatBorder Performs top-hat operation on an image.
MorphBlackhatBorder Performs black-hat operation on an image.
**MorphGradientBorder**  Calculates morphological gradient of an image.

**MorphAdvGetSize**

*Computes the size of the specification structure for advanced morphological operations.*

**Syntax**

**Case 2: Computing the size of morphology specification structure**

IppStatus ippiMorphAdvGetSize_<mod>(IppiSize roiSize, IppiSize maskSize, int* pSpecSize, int* pBufferSize);

Supported values for mod:

1u_C1R  8u_C1R  16u_C1R  16s_C1R  32f_C1R
8u_C3R          32f_C3R
8u_C4R          32f_C4R

**Include Files**

ippcv.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **roiSize**
  
  Maximal size of the image ROI (in pixels) that can be processed using the allocated structure.

- **maskSize**
  
  Size of the mask, in pixels.

- **pSpecSize**
  
  Pointer to the size of the morphology specification structure.

- **pBufferSize**
  
  Pointer to the size of the external buffer required for advanced morphological operations.

**Description**

This function operates with ROI.

This function computes the size of the specification structure and the size of the buffer required for advanced morphological operations. Call this function before using the ippiMorphAdvInit function.

For an example on how to use this function, see the code example provided with the ippiMorphCloseBorder function description.

**Return Values**

- **ippStsNoErr**
  
  Indicates no error.

- **ippStsNullPtrErr**
  
  Indicates an error when one of the specified pointers is NULL.

- **ippStsSizeErr**
  
  Indicates an error when maskSize or roiSize has a field with a zero or negative value.
See Also
Regions of Interest in Intel IPP
MorphAdvInit  Initializes the specification structure for advanced morphological operations.
MorphCloseBorder  Closes an image.

**MorphGetBufferSize**

*Computes the size of the working buffer for advanced morphological operations.*

**Syntax**

```c
IppStatus ippiMorphGetBufferSize_L(IppiSizeL roiSize, IppiSizeL maskSize, IppDataType dataType, int numChannels, IppSizeL* pBufferSize);
```

**Include Files**

ippcv_l.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- `roiSize`  Maximum size of the image ROI, in pixels.
- `maskSize`  Size of the structuring element.
- `dataType`  Data type for the processing function.
- `numChannels`  Number of channels in the image.
- `pBufferSize`  Pointer to the buffer size value for the initialization function.

**Description**

This function computes the size of the working buffer required for advanced morphological operations.

**Return Values**

- `ippStsNoErr`  Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr`  Indicates an error when one of the pointers is `NULL`.
- `ippStsSizeErr`  Width of the image, or width or height of the structuring element is less than, or equal to zero.

**MorphGetSpecSize**

*Computes the size of the internal state or specification structure for advanced morphological operations.*

**Syntax**

```c
ippiMorphGetSpecSize_L(IppiSizeL roiSize, IppiSizeL maskSize, IppDataType dataType, int numChannels, IppSizeL* pSpecSize);
```
Include Files
ippcv_l.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

roiSize
Maximum size of the image ROI, in pixels.

maskSize
Size of the structuring element.

dataType
Data type for the processing function.

numChannels
Number of channels in the image.

pSpecSize
Pointer to the size of the specification structure.

Description
This function computes the size of the specification structure for advanced morphological operations.

Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr
Indicates an error when one of the pointers is NULL.

ippStsSizeErr
Width of the image, or width or height of the structuring element is less than, or equal to zero.

MorphInit

Initializes the internal state or specification structure for advanced morphological operations.

Syntax
IppStatus ippiMorphInit_L( IppiSizeL roiSize, const Ipp8u* pMask, IppiSizeL maskSize, IppDataType dataType, int numChannels, IppiMorphAdvStateL* pMorphSpec);

Include Files
ippcv_l.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

roiSize
Maximum size of the image ROI, in pixels.

pMask
Pointer to the structuring element (mask).

maskSize
Size of the structuring element.
**MorphologyOperations**

**dataType**
- Data type for the processing function.

**numChannels**
- Number of channels in the image.

**pMorphSpec**
- Pointer to the advanced morphology specification structure.

**Description**

This function initializes the internal state or specification structure for advanced morphological operations.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when one of the pointers is **NULL**.
- **ippStsSizeErr**: Width of the image, or width or height of the structuring element is less than, or equal to zero.
- **ippStsAnchorErr**: Anchor point is outside the structuring element.

**MorphologyBorderGetSize**

*Computes the size of the morphology specification structure.*

**Syntax**

```c
IppStatus ippiMorphologyBorderGetSize_<mod>(IppiSize roiSize, IppiSize maskSize, int* pSpecSize, int* pBufferSize);
```

**Supported values for mod:**

- 1u_C1R, 8u_C1R, 16u_C1R, 16s_C1R, 32f_C1R
- 8u_C3R, 32f_C3R
- 8u_C4R, 32f_C4R

**Include Files**

ippcv.h

**Domain Dependencies**

- **Headers**: ippcore.h, ippvm.h, ipps.h, ippi.h
- **Libraries**: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

**Parameters**

- **roiSize**: Size of the image ROI, in pixels.
- **maskSize**: Size of the mask, in pixels.
- **pSpecSize**: Pointer to the size of the morphology specification structure.
- **pBufferSize**: Pointer to the size of the buffer required for dilation or erosion operations.

**Description**

This function operates with ROI.
This function computes the size of the morphology specification structure \( p\text{MorphSpec} \) and the size of the buffer required for dilation and erosion operations. Call this function before using the \( \text{ippiMorphologyBorderInit} \) function.

**Return Values**

- \( \text{ippStsNoErr} \): Indicates no error.
- \( \text{ippStsNullPtrErr} \): Indicates an error when one of the specified pointers is \( \text{NULL} \).
- \( \text{ippStsSizeErr} \): Indicates an error when \( \text{maskSize} \) has a field with a zero or negative value, or if width or height of \( \text{roiSize} \) is less than 1.

**See Also**

- Regions of Interest in Intel IPP
- \( \text{MorphologyBorderInit} \): Initializes the morphology specification structure for erosion or dilation operations.

---

**MorphologyBorderInit**

*Initializes the morphology specification structure for erosion or dilation operations.*

**Syntax**

\[
\text{IppStatus ippiMorphologyBorderInit\_<mod>(IppiSize roiSize, const Ipp8u* pMask, IppiSize maskSize, IppiMorphState* pSpec, Ipp8u* pBuffer);}\]

Supported values for \( \text{mod} \):

- \( 1u\_C1R \)
- \( 8u\_C1R \)
- \( 16u\_C1R \)
- \( 16s\_C1R \)
- \( 32f\_C1R \)
- \( 8u\_C3R \)
- \( 32f\_C3R \)
- \( 8u\_C4R \)
- \( 32f\_C4R \)

**Include Files**

\( \text{ippcv.h} \)

**Domain Dependencies**

- **Headers**: \( \text{ippcv.h, ippvm.h, ipps.h,ippi.h} \)
- **Libraries**: \( \text{ippcore.lib, ippvm.lib, ipps.lib,ippi.lib} \)

**Parameters**

- \( \text{roiSize} \): Size of the image ROI, in pixels.
- \( \text{pMask} \): Pointer to the mask.
- \( \text{maskSize} \): Size of the mask, in pixels.
- \( \text{pSpec} \): Pointer to the specification structure.
- \( \text{pBuffer} \): Pointer to the external buffer required for dilation or erosion operations.

**Description**

This function operates with ROI.
This function initializes the specification structure \(pSpec\) in the external buffer. Before using this function, you need to compute the size of the specification structure using the `MorphologyBorderGetSize` function. This structure is used by the `ippiDilateBorder` and `ippiErodeBorder` functions that perform morphological operations on the source image pixels corresponding to non-zero values of the structuring element (mask) \(pMask\).

**Return Values**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error when one of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error when (maskSize) has a field with a zero or negative value, or if width or height of (roiSize) is less than 1.</td>
</tr>
</tbody>
</table>

**See Also**

- Regions of Interest in Intel IPP
- `MorphologyBorderGetSize` Computes the size of the morphology specification structure.
- `DilateBorder` Performs dilation of an image.
- `ErodeBorder` Performs erosion of an image.

**MorphBlackhat**

*Performs top-hat operation on an image.*

**Syntax**

```c
IppStatus ippiMorphBlackhat_16u_C1R_L(const Ipp16u* pSrc, IppSizeL srcStep, Ipp16u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp16u* borderValue[1], const IppiMorphAdvStateL* pMorthSpec, Ipp8u* pBuffer);
```

```c
IppStatus ippiMorphBlackhat_16s_C1R_L(const Ipp16s* pSrc, IppSizeL srcStep, Ipp16s* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp16s* borderValue[1], const IppiMorphAdvStateL* pMorthSpec, Ipp8u* pBuffer);
```

```c
IppStatus ippiMorphBlackhat_1u_C1R_L(const Ipp8u* pSrc, IppSizeL srcStep, int srcBitOffset, Ipp8u* pDst, IppSizeL dstStep, int dstBitOffset, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u* borderValue[1], const IppiMorphAdvStateL* pMorthSpec, Ipp8u* pBuffer);
```

```c
IppStatus ippiMorphBlackhat_8u_C1R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, Ipp8u* borderValue[1], const IppiMorphAdvStateL* pMorthSpec, Ipp8u* pBuffer);
```

```c
IppStatus ippiMorphBlackhat_8u_C3R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, Ipp8u* borderValue[3], const IppiMorphAdvStateL* pMorthSpec, Ipp8u* pBuffer);
```

```c
IppStatus ippiMorphBlackhat_8u_C4R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, Ipp8u* borderValue[4], const IppiMorphAdvStateL* pMorthSpec, Ipp8u* pBuffer);
```

```c
IppStatus ippiMorphBlackhat_32f_C1R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, Ipp32f* borderValue[1], const IppiMorphAdvStateL* pMorthSpec, Ipp8u* pBuffer);
```
IppStatusippiMorphBlackhat_32f_C3R_L(constIpp32fpSrc,IppSizeLsrcStep,Ipp32fpDst,IppSizeLdstStep,IpplSizelroiSize,IpplBorderTypeborderType,constIpp32fborderValue[3],constIpplMorphAdvStateL*pMorthSpec,Ipp8upBuffer);

IppStatusippiMorphBlackhat_32f_C4R_L(constIpp32fpSrc,IppSizeLsrcStep,Ipp32fpDst,IppSizeLdstStep,IpplSizelroiSize,IpplBorderTypeborderType,constIpp32fborderValue[4],constIpplMorphAdvStateL*pMorthSpec,Ipp8upBuffer);

**Include Files**
ippcv_l.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**
  Pointer to the source image ROI.

- **srcStep**
  Distance, in bytes, between the starting points of consecutive lines in the source image.

- **srcBitOffset**
  Offset, in bits, from the first byte of the source image row.

- **pDst**
  Pointer to the destination image ROI.

- **dstStep**
  Distance, in bytes, between the starting points of consecutive lines in the destination image.

- **dstBitOffset**
  Offset, in bits, from the first byte of the destination image row.

- **roiSize**
  Size of the source and destination image ROI.

- **borderType**
  Type of border. Possible values are:

  - **ippBorderDefault**
    The border is set to ippBorderConst with borderValue=MAX_VALUE, where MAX_VALUE=IPP_MAX_8U/16U/16S/32F/1U

  - **ippBorderRepl**
    Border is replicated from the edge pixels.

  - **ippBorderMirror**
    Border pixels are mirrored from the source image boundary pixels.

  - **ippBorderConst**
    Values of all border pixels are set to a constant.

  - **ippBorderFirstStage**
    You can use this border type together with the ippBorderRepl, ippBorderMirror, ippBorderConst, ippBorderDefault types using the | operation. For the first stage, border pixels are obtained from the source image pixels in memory. For the second stage, the function uses the border type specified with the | operation.

  - **InMem**
    You can use this border type together with the ippBorderRepl, ippBorderMirror, ippBorderConst, ippBorderDefault types using the | operation. For the first stage, border pixels are obtained from the source image pixels in memory. For the second stage, the function uses the border type specified with the | operation.
Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, ippBorderDefault, or ippBorderMirror values and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight modifiers.

borderValue, borderValue[3], borderValue[4]  
Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

pMorphSpec  
Pointer to the morphology specification structure.

pBuffer  
Pointer to the external buffer.

Description

Before using this function, you need to initialize the morphology specification structure using the ippiMorphInit function.

This function performs a black-hat operation on a rectangular ROI area inside a one-, three-, or four-channel 2D image using a specified in the advanced morphology state or specification structure mask and the anchor cell.

The result is equivalent to the subtraction of the initial source image from the closed source image.

**NOTE**

The function can only process a ROI that does not exceed the maximum width and height roiSize specified by the initialization functions.

Return Values

- ippStsNoErr  
  Indicates no error.

- ippStsNullPtrErr  
  Indicates an error when one of the specified pointers is NULL.

- ippStsSizeErr  
  Indicates an error condition when:
  - roiSize has a field with a zero or negative value
  - ROI width is more than ROI width passed to the initialization function

- ippStsStepErr  
  Indicates an error condition when srcStep or dstStep is less than roiSize.width * <pixelSize>.

- ippStsNotEvenStepErr  
  Indicates an error when one of the step values is not a multiple of an element size.

- ippStsBadArgErr  
  Indicates an error when borderType has an illegal value.

See Also

Regions of Interest in Intel IPP
User-defined Border Types
MorphInit Initializes the internal state or specification structure for advanced morphological operations.
MorphBlackhatBorder

Performs black-hat operation on an image.

Syntax

IppStatus ippiMorphBlackhatBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, Ipp<datatype> borderValue, const IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C1R 16u_C1R 16s_C1R 32f_C1R

IppStatus ippiMorphBlackhatBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, const Ipp<datatype> borderValue[3], const IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C3R 32f_C3R

IppStatus ippiMorphBlackhatBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, const Ipp<datatype> borderValue[4], const IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C4R 32f_C4R

IppStatus ippiMorphBlackhatBorder_1u_C1R(const Ipp8u* pSrc, int srcStep, int srcBitOffset, Ipp8u* pDst, int dstStep, int dstBitOffset, IppiSize roiSize, IppiBorderType borderType, Ipp8u borderValue, const IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc
Pointer to the source image ROI.

srcStep
Distance, in bytes, between the starting points of consecutive lines in the source image.

srcBitOffset
Offset, in bits, from the first byte of the source image (for the 1u_C1R flavor).

pDst
Pointer to the destination image ROI.

dstStep
Distance, in bytes, between the starting points of consecutive lines in the destination image.
**dstBitOffset**
Offset, in bits, from the first byte of the destination image (for the 1u_C1R flavor).

**roiSize**
Size of the source and destination image ROI.

**borderType**
Type of border. Possible values are:
- ippBorderRepl  Border is replicated from the edge pixels.
- ippBorderInMem  Border is obtained from the source image pixels in memory.

**borderValue, borderValue[3], borderValue[4]**
Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

**pSpec**
Pointer to the specification structure.

**pBuffer**
Pointer to the external buffer.

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP).
This function performs black-hat operation on a rectangular ROI area inside a one-, three-, or four-channel 2D image using a specified in the advanced morphology specification structure mask and anchor cell. The structure must be initialized by MorphAdvInit beforehand.
The result is equivalent to the subtraction of the initial source image from the closed source image.

**NOTE**
The function can process only images with ROI that does not exceed the maximum width and height roiSize specified by the initialization functions.

**Return Values**
- ippStsNoErr  Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr  Indicates an error condition if one of the specified pointers is NULL.
- ippStsSizeErr  Indicates an error condition if roiSize has a field with a zero or negative value, or if one of ROI width or height is greater than corresponding size of ROI passed to the initialization functions.
- ippStsStepErr  Indicates an error condition if srcStep or dstStep is less than roiSize.width * <pixelSize>.
- ippStsNotEvenStepErr  Indicates an error condition if one of the step values is not divisible by 4 for floating-point images.
- ippStsBorderErr  Indicates an error condition if borderType has an illegal value.

**See Also**
MorphAdvInit  Initializes the specification structure for advanced morphological operations.
MorphClose

Closes an image.

Syntax

IppStatus ippiMorphClose_8u_C1R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppiSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[1], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);
IppStatus ippiMorphClose_8u_C3R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppiSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[3], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);
IppStatus ippiMorphClose_8u_C4R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppiSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[4], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);
IppStatus ippiMorphClose_16u_C1R_L(const Ipp16u* pSrc, IppSizeL srcStep, Ipp16u* pDst, IppSizeL dstStep, IppiSizeL roiSize, IppiBorderType borderType, const Ipp16u borderValue[1], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);
IppStatus ippiMorphClose_16s_C1R_L(const Ipp16s* pSrc, IppSizeL srcStep, Ipp16s* pDst, IppSizeL dstStep, IppiSizeL roiSize, IppiBorderType borderType, const Ipp16s borderValue[1], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);
IppStatus ippiMorphClose_1u_C1R_L(const Ipp8u* pSrc, IppSizeL srcStep, int srcBitOffset, Ipp8u* pDst, IppSizeL dstStep, int dstBitOffset, IppiSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[1], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);
IppStatus ippiMorphClose_32f_C1R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppiSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[1], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);
IppStatus ippiMorphClose_32f_C3R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppiSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[3], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);
IppStatus ippiMorphClose_32f_C4R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppiSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[4], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);

Include Files

ippcv_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc  
Pointer to the source image ROI.
srcStep  
Distance, in bytes, between the starting points of consecutive lines in the source image.
srcBitOffset  
Offset, in bits, from the first byte of the source image row.
pDst

dstStep

dstBitOffset

roiSize

borderType

Pointer to the destination image ROI.

Distance, in bytes, between the starting points of consecutive lines in the destination image.

Offset, in bits, from the first byte of the destination image row.

Size of the source and destination image ROI.

Type of border. Possible values are:

ippBorderDefault  The border is set to ippBorderConst with borderValue= MAX_VALUE, where MAX_VALUE=IPP_MAX_8U/16U/16S/32F/1U

ippBorderRepl  Border is replicated from the edge pixels.

ippBorderMirror  Border pixels are mirrored from the source image boundary pixels.

ippBorderConst  Values of all border pixels are set to a constant.

ippBorderFirstStage InMem  You can use this border type together with the ippBorderRepl, ippBorderMirror, ippBorderConst, ippBorderDefault types using the | operation. For the first stage, border pixels are obtained from the source image pixels in memory. For the second stage, the function uses the border type specified with the | operation.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, ippBorderDefault, or ippBorderMirror values and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight modifiers.

borderValue, borderValue[3], borderValue[4]  Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

pMorphSpec

pBuffer

Pointer to the morphology specification structure.

Pointer to the external buffer.

Description

Before using this function, you need to initialize the morphology specification structure using the ippiMorphInit function.

This function operates with ROI.

This function performs closing of a rectangular ROI area inside a one-, three-, or four-channel 2D image using the mask specified in the pMorphSpec structure.

The result is equivalent to successive dilation of the source image by the structured element (mask) and erosion by the reverted structured element.
NOTE
The function can only process a ROI that does not exceed the maximum width and height roiSize specified by the initialization functions.

Return Values

ippStsNoErr Indicates no error.
ippStsNullPtrErr Indicates an error when one of the specified pointers is NULL.
ippStsSizeErr Indicates an error condition when:
- roiSize has a field with a zero or negative value
- ROI width is more than ROI width passed to the initialization function
ippStsStepErr Indicates an error condition when srcStep or dstStep is less than roiSize.width * <pixelSize>.
ippStsNotEvenStepErr Indicates an error when one of the step values is not a multiple of an element size.
ippStsBadArgErr Indicates an error when borderType has an illegal value.

See Also
Regions of Interest in Intel IPP
User-defined Border Types
MorphInit Initializes the internal state or specification structure for advanced morphological operations.

MorphCloseBorder
Closes an image.

Syntax

IppStatus ippiMorphCloseBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, Ipp<datatype> borderValue, const IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u_C1R 16u_C1R 16s_C1R 32f_C1R

IppStatus ippiMorphCloseBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, const Ipp<datatype> borderValue[3], const IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u_C3R 32f_C3R
IppStatus ippiMorphCloseBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep,
Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, const
Ipp<datatype> borderValue[4], const IppMorphAdvState* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u_C4R  32f_C4R

IppStatus ippiMorphCloseBorder_1u_C1R(const Ipp8u* pSrc, int srcStep, int srcBitOffset,
Ipp8u* pDst, int dstStep, int dstBitOffset, IppiSize roiSize, IppiBorderType
borderType, Ipp8u borderValue, const IppMorphAdvState* pSpec, Ipp8u* pBuffer);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc       Pointer to the source image ROI.
srcStep    Distance, in bytes, between the starting points of consecutive
           lines in the source image.
srcBitOffset  Offset, in bits, from the first byte of the source image (for
                          1u_C1R flavor).
pDst       Pointer to the destination image ROI.
dstStep    Distance, in bytes, between the starting points of consecutive
           lines in the destination image.
dstBitOffset  Offset, in bits, from the first byte of the destination image (for
                          1u_C1R flavor).
roiSize    Size of the source and destination image ROI.
borderType  Type of border. Possible values are:
             ippBorderRepl  Border is replicated from the edge pixels.
             ippBorderInMem Border is obtained from the source image pixels in memory.
borderValue, borderValue[3],
borderValue[4]

pSpec       Pointer to the specification structure.
pBuffer

Description
Before using this function, you need to initialize the morphology specification structure using the
MorphAdvInit function.

This function operates with ROI.
This function performs closing of a rectangular ROI area inside a one-, three-, or four-channel 2D image using the mask specified in the pSpec structure.

The result is equivalent to successive dilation of the source image by the structured element (mask) and erosion by the reverted structured element.

**NOTE**

This function requires that the image ROI does not exceed the maximum width and height roiSize specified by the initialization functions.

Usage example of this function is similar to the example provided with the MorphOpenBorder function description.

## Return Values

- **ippStsNoErr**
  Indicates no error.

- **ippStsNullPtrErr**
  Indicates an error when one of the specified pointers is NULL.

- **ippStsSizeErr**
  Indicates an error condition when:
  - roiSize has a field with a zero or negative value
  - one of the ROI width or height is more than the corresponding size of ROI passed to the initialization functions
  - srcBitOffset or dstBitOffset is less than zero

- **ippStsStepErr**
  Indicates an error condition if srcStep or dstStep is less than roiSize.width * <pixelSize>.

- **ippStsNotEvenStepErr**
  Indicates an error condition if one of the step values for 16-bit integer images is not divisible by 2.

- **ippStsBorderErr**
  Indicates an error condition if borderType has an illegal value.

## Example

The code example below demonstrates how to use the ippiMorphAdvGetSize_16u_C1R, ippiMorphAdvInit_16u_C1R, and ippiMorphCloseBorder_16u_C1R functions.

```c
IppStatus func_MorfCloseBorder()
{
    IppiMorphAdvState* pSpec = NULL;
    Ipp8u* pBuffer = NULL;
    IppiSize roiSize = {5, 5};
    Ipp8u pMask[3*3] = {1, 1, 1,
                        1, 0, 1,
                        1, 1, 1};
    IppiSize maskSize = {3, 3};
    Ipp16u pSrc[5*5] = { 1, 2, 4, 1, 2,
                         5, 1, 2, 1, 2,
                         1, 2, 1, 2, 1,
                         2, 1, 5, 1, 2};
    Ipp16u pDst[5*5];
    int srcStep = 5*sizeof(Ipp16u);
    int dstStep = 5*sizeof(Ipp16u);
    int dstSize = 5;
    IppStatus status = ippStsNoErr;
    int specSize = 0, bufferSize = 0;
    Ipp1BorderType borderType = ippBorderRepl;
```
Ipp16u borderValue = 0;

status = ippiMorphAdvGetSize_16u_C1R( roiSize, maskSize, &specSize, &bufferSize);
if (status != ippStsNoErr) return status;

pSpec = (IppiMorphAdvState*)ippsMalloc_8u(specSize);
pBuffer = (Ipp8u*)ippsMalloc_8u(bufferSize);

status = ippiMorphAdvInit_16u_C1R( roiSize, pMask, maskSize, pSpec, pBuffer );
if (status != ippStsNoErr) {
    ippsFree(pBuffer);
    ippsFree(pSpec);
    return status;
}

status = ippiMorphCloseBorder_16u_C1R (pSrc, srcStep, pDst, dstStep, roiSize, borderType,
borderValue, pSpec, pBuffer);

ippsFree(pBuffer);
ippsFree(pSpec);
return status;

The result is as follows:

pDst->
5 4 4 2 2
5 4 4 2 2
2 2 2 2 2
2 2 5 2 2
2 2 2 2 2

See Also
Regions of Interest in Intel IPP
User-defined Border Types
MorphAdvInit  Initializes the specification structure for advanced morphological operations.

**MorphGradient**

*Calculates morphological gradient of an image.*

**Syntax**

IppStatus ippiMorphGradient_16u_C1R_L(const Ipp16u* pSrc, IppSizeL srcStep, Ipp16u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp16u borderValue[1], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiMorphGradient_16s_C1R_L(const Ipp16s* pSrc, IppSizeL srcStep, Ipp16s* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp16s borderValue[1], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiMorphGradient_1u_C1R_L(const Ipp8u* pSrc, IppSizeL srcStep, int srcBitOffset, Ipp8u* pDst, IppSizeL dstStep, int dstBitOffset, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[1], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);
IppStatus ippiMorphGradient_8u_C1R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[1], const IppMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);
IppStatus ippiMorphGradient_8u_C3R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[3], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);
IppStatus ippiMorphGradient_8u_C4R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[4], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);
IppStatus ippiMorphGradient_32f_C1R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[1], const IppMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);
IppStatus ippiMorphGradient_32f_C3R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[3], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);
IppStatus ippiMorphGradient_32f_C4R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[4], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);

Include Files
ippcv_l.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
pSrc
Pointer to the source image ROI.
srcStep
Distance, in bytes, between the starting points of consecutive lines in the source image.
srcBitOffset
Offset, in bits, from the first byte of the source image row.
pDst
Pointer to the destination image ROI.
dstStep
Distance, in bytes, between the starting points of consecutive lines in the destination image.
dstBitOffset
Offset, in bits, from the first byte of the destination image row.
roiSize
Size of the source and destination image ROI.
borderType
Type of border. Possible values are:
ippBorderDefault
The border is set to ippBorderConst with borderValue= MAX_VALUE, where MAX_VALUE=IPP_MAX_8U/16U/16S/32F/1U
ippBorderRepl
Border is replicated from the edge pixels.
ippBorderMirror
Border pixels are mirrored from the source image boundary pixels.
### Description

Before using this function, you need to initialize the morphology specification structure using the `ippiMorphInit` function.

This function calculates a morphological gradient of a rectangular ROI area inside a one-, three-, or four-channel 2D image using a specified in the advanced morphology specification structure mask and anchor cell.

The result is equivalent to the subtraction of an opened source image from a closed source image.

**NOTE**

The function can only process a ROI that does not exceed the maximum width and height `roiSize` specified by the initialization functions.

### Return Values

- **ippStsNoErr**
  - Indicates no error.

- **ippStsNullPtrErr**
  - Indicates an error when one of the specified pointers is NULL.

- **ippStsSizeErr**
  - Indicates an error condition when:
    - `roiSize` has a field with a zero or negative value
    - ROI width is more than ROI width passed to the initialization function

- **ippStsStepErr**
  - Indicates an error condition when `srcStep` or `dstStep` is less than `roiSize.width * <pixelSize>`.

- **ippStsNotEvenStepErr**
  - Indicates an error when one of the step values is not a multiple of an element size.
Indicates an error when borderType has an illegal value.

See Also
Regions of Interest in Intel IPP
User-defined Border Types
MorphInit Initializes the internal state or specification structure for advanced morphological operations.

**MorphGradientBorder**

Calculates morphological gradient of an image.

IppStatus ippiMorphGradientBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, Ipp<datatype> borderValue, const IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C1R 16u_C1R 16s_C1R 32f_C1R

IppStatus ippiMorphGradientBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, const Ipp<datatype> borderValue[3], const IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C3R 32f_C3R

IppStatus ippiMorphGradientBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, const Ipp<datatype> borderValue[4], const IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C4R 32f_C4R

IppStatus ippiMorphGradientBorder_1u_C1R(const Ipp8u* pSrc, int srcStep, int srcBitOffset, Ipp8u* pDst, int dstStep, int dstBitOffset, IppiSize roiSize, IppiBorderType borderType, Ipp8u borderValue, const IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Include Files
ippcv.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

*pSrc*

Pointer to the source image ROI.

*srcStep*

Distance in bytes between starts of consecutive lines in the source image.
Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function calculates a morphological gradient of a rectangular ROI area inside a one-, three-, or four-channel 2D image using a specified in the advanced morphology specification structure mask and anchor cell. The structure must be initialized by MorphAdvInit beforehand.

The result is equivalent to the subtraction of an opened source image from a closed source image.

NOTE
The function can process only images with ROI that does not exceed the maximum width and height roiSize specified by the initialization functions.

Return Values
ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error condition if one of the specified pointers is NULL.
ippStsSizeErr Indicates an error condition if roiSize has a field with a zero or negative value, or if one of ROI width or height is greater than corresponding size of ROI passed to the initialization functions.
ippStsStepErr Indicates an error condition if srcStep or dstStep is less than roiSize.width * <pixelSize>.
ippStsNotEvenStepErr Indicates an error condition if one of the step values is not divisible by 4 for floating-point images.
ippStsBorderErr Indicates an error condition if borderType has an illegal value.

See Also
MorphAdvInit Initializes the specification structure for advanced morphological operations.
MorphOpen

Opens an image.

Syntax

IppStatus ippiMorphOpen_16u_C1R_L(const Ipp16u* pSrc, IppSizeL srcStep, Ipp16u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp16u borderValue[1], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiMorphOpen_16s_C1R_L(const Ipp16s* pSrc, IppSizeL srcStep, Ipp16s* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp16s borderValue[1], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiMorphOpen_1u_C1R_L(const Ipp8u* pSrc, IppSizeL srcStep, int srcBitOffset, Ipp8u* pDst, IppSizeL dstStep, int dstBitOffset, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[1], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiMorphOpen_8u_C1R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[1], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiMorphOpen_8u_C3R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[3], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiMorphOpen_8u_C4R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[4], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiMorphOpen_32f_C1R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[1], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiMorphOpen_32f_C3R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[3], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);

IppStatus ippiMorphOpen_32f_C4R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[4], const IppiMorphAdvStateL* pMorphSpec, Ipp8u* pBuffer);

Include Files

ippcv_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc

tPointer to the source image ROI.

srcStep

Distance, in bytes, between the starting points of consecutive lines in the source image.

srcBitOffset

Offset, in bits, from the first byte of the source image row.
pDst

dstStep

dstBitOffset

roiSize

borderType

Pointer to the destination image ROI.

Distance, in bytes, between the starting points of consecutive lines in the destination image.

Offset, in bits, from the first byte of the destination image row.

Size of the source and destination image ROI.

Type of border. Possible values are:

ippBorderDefault  The border is set to ippBorderConst with borderValue= MAX_VALUE, where

MAX_VALUE=IPP_MAX_8U/16U/16S/32F/1U

ippBorderRepl  Border is replicated from the edge pixels.

ippBorderMirror  Border pixels are mirrored from the source image boundary pixels.

ippBorderConst  Values of all border pixels are set to a constant.

ippBorderFirstStageInMem

You can use this border type together with the ippBorderRepl, ippBorderMirror, ippBorderConst, ippBorderDefault types using the | operation. For the first stage, border pixels are obtained from the source image pixels in memory. For the second stage, the function uses the border type specified with the | operation.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, ippBorderDefault, or ippBorderMirror values and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight modifiers.

borderValue, borderValue[3], borderValue[4]

Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

pMorphSpec

Pointer to the morphology specification structure.

pBuffer

Pointer to the external buffer.

Description

Before using this function, you need to initialize the morphology specification structure using the ippiMorphInit function.

This function operates with ROI.

This function performs opening of a rectangular ROI area inside a one-, three-, or four-channel 2D image using the mask specified in the pMorphSpec structure.

The result is equivalent to successive dilation of the source image by the structured element (mask) and erosion by the reverted structured element.
NOTE
The function can only process a ROI that does not exceed the maximum width and height roiSize specified by the initialization functions.

Return Values

ippStsNoErr
Indicates no error.

ippStsNullPtrErr
Indicates an error when one of the specified pointers is NULL.

ippStsSizeErr
Indicates an error condition when:
- roiSize has a field with a zero or negative value
- ROI width is more than ROI width passed to the initialization function

ippStsStepErr
Indicates an error condition when srcStep or dstStep is less than roiSize.width * pixelSize.

ippStsNotEvenStepErr
Indicates an error when one of the step values is not a multiple of an element size.

ippStsBadArgErr
Indicates an error when borderType has an illegal value.

See Also
Regions of Interest in Intel IPP
User-defined Border Types
MorphInit Initializes the internal state or specification structure for advanced morphological operations.

MorphOpenBorder
Opens an image.

Syntax

IppStatus ippiMorphOpenBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, Ipp<datatype> borderValue, const IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u_C1R 16u_C1R 16s_C1R 32f_C1R

IppStatus ippiMorphOpenBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, const Ipp<datatype> borderValue[3], const IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u_C3R 32f_C3R
IppStatus ippiMorphOpenBorder\_<mod>(const Ipp<datatype>\* pSrc, int srcStep, Ipp<datatype>\* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType, const Ipp<datatype> borderValue[4], const IppiMorphAdvState* pSpec, Ipp8u\* pBuffer);

Supported values for mod:

- 8u\_C4R
- 32f\_C4R

IppStatus ippiMorphOpenBorder\_1u\_C1R(const Ipp8u\* pSrc, int srcStep, int srcBitOffset, Ipp8u\* pDst, int dstStep, int dstBitOffset, IppiSize roiSize, IppiBorderType borderType, Ipp8u borderValue, const IppiMorphAdvState* pSpec, Ipp8u\* pBuffer);

**Include Files**

ippcv.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance, in bytes, between the starting points of consecutive lines in the source image.
- **srcBitOffset**: Offset, in bits, from the first byte of the source image (for the 1u\_C1R flavor).
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance, in bytes, between the starting points of consecutive lines in the destination image.
- **dstBitOffset**: Offset, in bits, from the first byte of the destination image (for the 1u\_C1R flavor).
- **roiSize**: Size of the source and destination image ROI.
- **borderType**: Type of border. Possible values are:
  - ippBorderRepl: Border is replicated from the edge pixels.
  - ippBorderInMem: Border is obtained from the source image pixels in memory.
- **borderValue**, **borderValue[3]**, **borderValue[4]**: Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.
- **pSpec**: Pointer to the specification structure.
- **pBuffer**: Pointer to the external buffer required for dilation operations.

**Description**

Before using this function, you need to initialize the morphology specification structure by using MorphAdvInit function.

This function operates with ROI.
This function performs opening of a rectangular ROI area inside a one-, three-, or four-channel 2D image using the mask specified in the pSpec structure.

The result is equivalent to successive dilation of the source image by the structured element (mask) and erosion by the reverted structured element.

**NOTE**
The function can only process a ROI that does not exceed the maximum width and height roiSize specified by the initialization functions.

### Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error when one of the specified pointers is `NULL`.
- **ippStsSizeErr**: Indicates an error condition when:
  - roiSize has a field with a zero or negative value
  - one of the ROI width or height is more than the corresponding size of ROI passed to the initialization functions
  - srcBitOffset or dstBitOffset is less than zero
- **ippStsStepErr**: Indicates an error condition if srcStep or dstStep is less than roiSize.width * <pixelSize>.
- **ippStsNotEvenStepErr**: Indicates an error condition if one of the step values for 16-bit integer images is not divisible by 2.
- **ippStsBorderErr**: Indicates an error condition if borderType has an illegal value.

### See Also
- Regions of Interest in Intel IPP
- User-defined Border Types
- MorphAdvInit  Initializes the specification structure for advanced morphological operations.

### MorphTophat

**Performs top-hat operation on an image.**

**Syntax**

```c
IppStatus ippiMorphTophat_16u_C1R_L(const Ipp16u* pSrc, IppSizeL srcStep, Ipp16u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp16u* borderValue[1], const IppiMorphAdvStateL* pMorthSpec, Ipp8u* pBuffer);
IppStatus ippiMorphTophat_16s_C1R_L(const Ipp16s* pSrc, IppSizeL srcStep, Ipp16s* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp16s* borderValue[1], const IppiMorphAdvStateL* pMorthSpec, Ipp8u* pBuffer);
IppStatus ippiMorphTophat_1u_C1R_L(const Ipp8u* pSrc, IppSizeL srcStep, int srcBitOffset, Ipp8u* pDst, IppSizeL dstStep, int dstBitOffset, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u* borderValue[1], const IppiMorphAdvStateL* pMorthSpec, Ipp8u* pBuffer);
IppStatus ippiMorphTophat_8u_C1R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp8u* borderValue[1], const IppiMorphAdvStateL* pMorthSpec, Ipp8u* pBuffer);
```
IppStatus ippiMorphTophat_8u_C3R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppiSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[3], const IppiMorphAdvStateL* pMorthSpec, Ipp8u* pBuffer);

IppStatus ippiMorphTophat_8u_C4R_L(const Ipp8u* pSrc, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstStep, IppiSizeL roiSize, IppiBorderType borderType, const Ipp8u borderValue[4], const IppiMorphAdvStateL* pMorthSpec, Ipp8u* pBuffer);

IppStatus ippiMorphTophat_32f_C1R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppiSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[1], const IppiMorphAdvStateL* pMorthSpec, Ipp8u* pBuffer);

IppStatus ippiMorphTophat_32f_C3R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppiSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[3], const IppiMorphAdvStateL* pMorthSpec, Ipp8u* pBuffer);

IppStatus ippiMorphTophat_32f_C4R_L(const Ipp32f* pSrc, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstStep, IppiSizeL roiSize, IppiBorderType borderType, const Ipp32f borderValue[4], const IppiMorphAdvStateL* pMorthSpec, Ipp8u* pBuffer);

Include Files
ippcv_l.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

* **pSrc**
  Pointer to the source image ROI.
* **srcStep**
  Distance, in bytes, between the starting points of consecutive lines in the source image.
* **srcBitOffset**
  Offset, in bits, from the first byte of the source image row.
* **pDst**
  Pointer to the destination image ROI.
* **dstStep**
  Distance, in bytes, between the starting points of consecutive lines in the destination image.
* **dstBitOffset**
  Offset, in bits, from the first byte of the destination image row.
* **roiSize**
  Size of the source and destination image ROI.
* **borderType**
  Type of border. Possible values are:
  
  * **ippBorderDefault**
    The border is set to *ippBorderConst* with $\text{borderValue} = \text{MAX\_VALUE}$, where $\text{MAX\_VALUE} = \text{IPP\_MAX\_8U/16U/16S/32F/1U}$
  
  * **ippBorderRepl**
    Border is replicated from the edge pixels.
  
  * **ippBorderMirror**
    Border pixels are mirrored from the source image boundary pixels.
  
  * **ippBorderConst**
    Values of all border pixels are set to a constant.
ippBorderFirstStageInMem

You can use this border type together with the ippBorderRepl, ippBorderMirror, ippBorderConst, ippBorderDefault types using the | operation. For the first stage, border pixels are obtained from the source image pixels in memory. For the second stage, the function uses the border type specified with the | operation.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, ippBorderDefault, or ippBorderMirror values and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight modifiers.

borderValue, borderValue[3], borderValue[4]

Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

pMorphSpec

Pointer to the morphology specification structure.

pBuffer

Pointer to the external buffer.

Description

Before using this function, you need to initialize the morphology specification structure using theippiMorphInit function.

This function performs a top-hat operation on a rectangular ROI area inside a one-, three-, or four-channel 2D image using a specified in the advanced morphology state or specification structure mask and the anchor cell.

The result is equivalent to the opening the source image and following subtraction from the initial source image.

NOTE
The function can only process a ROI that does not exceed the maximum width and height roiSize specified by the initialization functions.

Return Values

ippStsNoErr
Indicates no error.

ippStsNullPtrErr
Indicates an error when one of the specified pointers is NULL.

ippStsSizeErr
Indicates an error condition when:
• roiSize has a field with a zero or negative value
• ROI width is more than ROI width passed to the initialization function

ippStsStepErr
Indicates an error condition when srcStep or dstStep is less than roiSize.width * <pixelSize>.

ippStsNotEvenStepErr
Indicates an error when one of the step values is not a multiple of an element size.

ippStsBadArgErr
Indicates an error when borderType has an illegal value.
See Also
Regions of Interest in Intel IPP
User-defined Border Types
MorphInit Initializes the internal state or specification structure for advanced morphological operations.

MorphTophatBorder

*Performs top-hat operation on an image.*

Syntax

**Case 1: Operating with morphology state structure**

IppStatusippiMorphTophatBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep,
Ipp<datatype>* pDst, int dstStep, IppSize roiSize, IppiBorderType borderType,
Ipp<datatype> borderValue, const IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Supported values for mod:

- 8u_C1R  32f_C1R

IppStatusippiMorphTophatBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep,
Ipp<datatype>* pDst, int dstStep, IppSize roiSize, IppiBorderType borderType, const
Ipp<datatype> borderValue[3], const IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Supported values for mod:

- 8u_C3R  32f_C3R

IppStatusippiMorphTophatBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep,
Ipp<datatype>* pDst, int dstStep, IppSize roiSize, IppiBorderType borderType, const
Ipp<datatype> borderValue[4], const IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Supported values for mod:

- 8u_C4R  32f_C4R

**Case 2: Operating with morphology specification structure**

IppStatusippiMorphTophatBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep,
Ipp<datatype>* pDst, int dstStep, IppSize roiSize, IppiBorderType borderType,
Ipp<datatype> borderValue, const IppiMorphAdvState* pSpec, Ipp8u* pBuffer);

Supported values for mod:

- 16u_C1R  16s_C1R

IppStatusippiMorphTophatBorder_1u_C1R(const Ipp8u* pSrc, int srcStep, int
srcBitOffset, Ipp8u* pDst, int dstStep, int dstBitOffset, IppSize roiSize,
IppiBorderType borderType, Ipp8u borderValue, const IppiMorphAdvState* pSpec, Ipp8u*
pBuffer);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc  
Pointer to the source image ROI.

srcStep  
Distance, in bytes, between the starting points of consecutive lines in the source image.

srcBitOffset  
Offset, in bits, from the first byte of the source image (for the 1u_C1R flavor).

pDst  
Pointer to the destination image ROI.

dstStep  
Distance, in bytes, between the starting points of consecutive lines in the destination image.

dstBitOffset  
Offset, in bits, from the first byte of the destination image (for the 1u_C1R flavor).

roiSize  
Size of the source and destination image ROI.

borderType  
Type of border. Possible values are:

ippBorderRepl  
Border is replicated from the edge pixels.

ippBorderInMem  
Border is obtained from the source image pixels in memory.

borderValue, borderValue[3], borderValue[4]  
Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

pSpec  
Pointer to the specification structure.

pBuffer  
Pointer to the external buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function performs a top-hat operation on a rectangular ROI area inside a one-, three-, or four-channel 2D image using a specified in the advanced morphology state or specification structure mask and the anchor cell. The structure must be initialized by MorphAdvInit beforehand.

The result is equivalent to the opening the source image and following subtraction from the initial source image.

NOTE
The function can process only images with ROI that does not exceed the maximum width and height roiSize specified by the initialization functions.

Return Values

ippStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  
Indicates an error condition if one of the specified pointers is NULL.
Indicates an error condition if roiSize has a field with a zero or negative value, or if one of ROI width or height is greater than corresponding size of ROI passed to the initialization functions.

Indicates an error condition if srcStep or dstStep is less than roiSize.width * <pixelSize>.

Indicates an error condition if one of the step values is not divisible by 4 for floating-point images.

Indicates an error condition if borderType has an illegal value.

See Also
MorphAdvInit Initializes the specification structure for advanced morphological operations.

MorphGrayInit

Initializes morphology state structure for gray-kernel morphology operations.

Syntax
IppStatus ippiMorphGrayInit_8u_C1R(IppiMorphGrayState_8u* pState, IppiSize roiSize, const Ipp32s* pMask, IppiSize maskSize, IppiPoint anchor);
IppStatus ippiMorphGrayInit_32f_C1R(IppiMorphGrayState_32f* pState, IppiSize roiSize, const Ipp32f* pMask, IppiSize maskSize, IppiPoint anchor);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pState Pointer to the gray-kernel morphology state structure.
roiSize Maximal size of the image ROI in pixels, that can be processed using the allocated structure.
pMask Pointer to the mask.
maskSize Size of the mask in pixels.
anchor Coordinates of the anchor cell.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function initializes the gray-kernel morphology state structure pState in the external buffer. Its size should be computed by the function MorphGrayGetSize. It is used by the functions GrayDilateBorder and GrayErodeBorder that perform gray-kernel dilation and erosion of the source image pixels corresponding to the specified pMask of size maskSize. The anchor cell anchor is positioned in the arbitrary point in the mask and is used for positioning the mask.
**WARNING**
The structure can be used to process images with ROI that does not exceed the specified maximum width and height `roiSize`.

**Return Values**

- `ippStsNoErr`: Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr`: Indicates an error when one of the specified pointers is `NULL`.
- `ippStsSizeErr`: Indicates an error condition if `maskSize` or if `roiSize` has a field with a zero or negative value.
- `ippStsAnchorErr`: Indicates an error if `anchor` is outside the mask.

**MorphGrayGetSize**

*Computes the size of the gray-kernel morphology state structure.*

**Syntax**

```c
IppStatus ippiMorphGrayGetSize_8u_C1R(IppiSize roiSize, const Ipp32s* pMask, IppiSize maskSize, int* pSize);
IppStatus ippiMorphGrayGetSize_32f_C1R(IppiSize roiSize, const Ipp32f* pMask, IppiSize maskSize, int* pSize);
```

**Include Files**

`ippcv.h`

**Domain Dependencies**

- Headers: `ippcore.h`, `ippvm.h`, `ipps.h`, `ippi.h`
- Libraries: `ippcore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`

**Parameters**

- `roiSize`: Maximal size of the image ROI in pixels, that can be processed using the allocated structure.
- `pMask`: Pointer to the mask.
- `maskSize`: Size of the mask in pixels.
- `pSize`: Pointer to the size of the advanced morphology state structure.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function computes the size of the morphology state structure `pState` for gray-kernel dilation and erosion. This function should be run prior to the function `MorphGrayInit`. 
Return Values

ippiStsNoErr
Indicates no error. Any other value indicates an error or a warning.

ippiStsNullPtrErr
Indicates an error when one of the specified pointers is NULL.

ippiStsSizeErr
Indicates an error condition if maskSize or if roiSize has a field with a zero or negative value.

MorphReconstructGetBufferSize

Computes the size of the buffer for morphological reconstruction operation.

IppStatus ippiMorphReconstructGetBufferSize(IppiSize roiSize, IppDataType dataType, int numChannels, int* pBufSize);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

roiSize
Maximal size of the image ROI in pixels, that can be processed using the buffer.

dataType
Data type of the image.

numChannels
Number of channels in the image.

pBufSize
Pointer to the size of the work buffer (in bytes), returned by the ippiMorphReconstructGetBufferSize function.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function computes the size of the buffer for the morphological reconstruction of the source image. This buffer can be used by the functions MorphReconstructDilate and MorphReconstructErode.

Return Values

ippiStsNoErr
Indicates no error. Any other value indicates an error or a warning.

ippiStsNullPtrErr
Indicates an error condition if pSize is NULL.

ippiStsSizeErr
Indicates an error condition if roiSize has a field with a zero or negative value.
MorphReconstructDilate

Reconstructs an image by dilation.

Syntax

IppStatus ippiMorphReconstructDilate_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp8u* pBuffer, IppiNorm norm);

Supported values for mod:

- 8u_C1IR
- 16u_C1IR
- 64f_C1IR

IppStatus ippiMorphReconstructDilate_32f_C1IR(const Ipp32f* pSrc, int srcStep, Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp32f* pBuffer, IppiNorm norm);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters

- pSrc: Pointer to the source image ROI.
- srcStep: Distance in bytes between starts of consecutive lines in the source image.
- pSrcDst: Pointer to the decreased and reconstructed image ROI.
- srcDstStep: Distance in bytes between starts of consecutive lines in the decreased and reconstructed image.
- roiSize: Size of the source and destination image ROI.
- norm: Type of norm to form the mask for dilation; the following values are possible:
  - ippiNormInf: Infinity norm (8-connectivity, 3x3 rectangular mask).
  - ippiNormL1: L1 norm (4-connectivity, 3x3 cross mask).
- pBuffer: Pointer to the buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function performs morphological reconstruction of the decreased source image by dilation [Vincent93]. The operation is performed in the working buffer whose size should be computed using the function MorphReconstructGetBufferSize beforehand.

This operation enables detection of the regional maximums that can be used as markers for successive watershed segmentation.
Example below shows how the morphological reconstruction can be used to build markers of objects with different brightness. Some value (cap size) is subtracted from the initial image and then the subtracted image is reconstructed to the initial one. Thresholding and opening complete the building of markers. The figure below shows the results of these operations.

**Building Markers for Segmentation by the Morphological Reconstruction**

![Initial Image](image1)
![Initial Image Decreased by the Cap Value](image2)
![Reconstructed Image](image3)
![Cap Image](image4)
![Thresholded Caps](image5)
![Markers](image6)

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**
  Indicates an error condition if one of the specified pointers is NULL.

- **ippStsSizeErr**
  Indicates an error condition if `roiSize` has a field with a zero or negative value.

- **ippStsStepErr**
  Indicates an error condition if `srcStep` or `srcDstStep` is less than `roiSize.width * <pixelSize>`. 

- **ippStsNotEvenStepErr**
  Indicates an error condition if one of the step values is not divisible by 4 for floating-point images.

- **ippStsBadArgErr**
  Indicates an error condition if `norm` has an illegal value.

**Example**

To better understand usage of this function, refer to the `MorphReconstructDilate.c` example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.
MorphReconstructErode

Reconstructs an image by erosion.

Syntax

IppStatus ippiMorphReconstructErode_\texttt{<mod>}(const Ipp\texttt{<datatype>}* pSrc, int srcStep, Ipp\texttt{<datatype>}* pSrcDst, int srcDstStep, IppSize roiSize, Ipp8u* pBuf, IppiNorm norm);

Supported values for \texttt{mod}:

- \texttt{8u\_C1IR}
- \texttt{16u\_C1IR}
- \texttt{64f\_C1IR}

IppStatus ippiMorphReconstructErode_\texttt{32f\_C1IR}(const Ipp32f* pSrc, int srcStep, Ipp32f* pSrcDst, int srcDstStep, IppSize roiSize, Ipp32f* pBuf, IppiNorm norm);

Include Files

ippcv.h.

Parameters

- \texttt{pSrc}
  - Pointer to the source image ROI.
- \texttt{srcStep}
  - Distance in bytes between starts of consecutive lines in the source image.
- \texttt{pSrcDst}
  - Pointer to the decreased and reconstructed image ROI.
- \texttt{srcDstStep}
  - Distance in bytes between starts of consecutive lines in the decreased and reconstructed image.
- \texttt{roiSize}
  - Size of the source and destination image ROI.
- \texttt{norm}
  - Type of norm to form the mask for dilation; the following values are possible:
    - \texttt{ippiNormInf}
      - Infinity norm (8-connectivity, 3x3 rectangular mask).
    - \texttt{ippiNormL1}
      - L1 norm (4-connectivity, 3x3 cross mask).
- \texttt{pBuf}
  - Pointer to the buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function performs morphological reconstruction of the increased source image by erosion \cite{Vincent93}. The operation is performed in the working buffer whose size should be computed using the function \texttt{MorphReconstructGetBufferSize} beforehand.

This operation enables detection of the regional minimums that can be used as markers for successive watershed segmentation.

Return Values

- \texttt{ippStsNoErr}
  - Indicates no error. Any other value indicates an error or a warning.
- \texttt{ippStsNullPtrErr}
  - Indicates an error condition if one of the specified pointers is NULL.
MorphSetMode

Sets the mask processing mode for advanced morphological operations.

Syntax
IppStatus ippiMorphSetMode(int mode, IppiMorphAdvState* pMorphSpec);
IppStatus ippiMorphSetMode_L(int mode, IppiMorphAdvStateL* pMorphSpec);

Include Files
ippcv.h
ippcv_l.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
mode
Mask processing mode; supported values:
IPP_MORPH_DEFAULT Invert the mask
IPP_MORPH_MASK_NO_FLIP Do not invert the mask; use the same mask for the first and second stage.

pMorphSpec
Pointer to the specification structure for advanced morphological operations.

Description
This function sets the mask processing mode for the second stage of an advanced morphological operation. Before using this function, initialize the specification structure using the ippiMorphInit function.

Return Values
ippStsNoErr
Indicates no error.
ippStsNotSupportedModeErr
Indicates an error when mode has an invalid value.
ippStsNullPtrErr
Indicates an error when pMorphSpec is NULL.
See Also

MorphInit Initializes the internal state or specification structure for advanced morphological operations.
Filtering Functions

This section describes the Intel® IPP image processing functions that perform linear and non-linear filtering operations on an image.

You can use filtering in image processing operations like edge detection, blurring, noise removal, and feature detection.

Most filtering functions operate with regions of interest (ROI). The size of the source image ROI is equal to the destination image ROI size \( \text{dstRoiSize} \). Most functions use different source and destination image buffers. These functions are not in-place.

See Also
Regions of Interest in Intel IPP

Borders in Neighborhood Operations

Filtering functions described in this section perform neighborhood operations. They operate on the assumption that for each pixel to be processed, all neighborhood pixels required for the operation are also available.

The neighborhood for each given pixel is defined by the filter kernel (or mask) size and anchor cell position. For more information about anchors and how to define the anchor cell position refer to Neighborhood Operations.

As the following figure illustrates, if the input pixel is near the horizontal or vertical edge of the image, the overlaid kernel may refer to neighborhood pixels that do not exist within the source image and are located outside the image area.

The set of all boundary source image pixels that require such non-existent pixels to complete the neighborhood operation for the given kernel and anchor is shaded yellow, while the collection of all scanned external pixels (called \( \text{border} \) pixels) is shaded gray.

If you want to apply some filtering operation to the whole source image, you must figure out what additional border pixels are required for the operation, and define these non-existent pixels. To do this, you can use the Intel IPP functions `ippiCopyConstBorder`, `ippiCopyReplicateBorder`, or `ippiCopyWrapBorder`, which fill the border of the extended image with the pixel values that you define, or you can apply your own extension method.

**Note**
If the required border pixels are not defined prior to the filtering function call, you may get memory violation errors.
If you want to apply the filtering operation to the part of the source image, or ROI, then the necessity of extending the image area with border pixels depends on the ROI size and position within the image. The figure below shows that if ROI does not cover yellow (internal boundary) pixels, then no external pixels are scanned, and border extension is not required.

![Source ROI](image.png)

If boundary pixels are part of ROI, you still need to extend some area of the source image.

To provide valid results of filtering operations, the application must check the following:

- ROI parameters passed to the filtering function have such values
- All required neighborhood pixels actually exist in the image and define the missing pixels when necessary.

See Also

- Neighborhood Operations
- Regions of Interest in Intel IPP
- User-defined Border Types

CopyConstBorder

CopyReplicateBorder

CopyWrapBorder

User-defined Border Types

Some of the Intel® IPP image processing functions operate on user-defined border types. It means that the values of border pixels are assigned in accordance with the `borderType` (or `border`) and `borderValue` parameters.

Intel® IPP supports the following border types:

- Constant border
- Replicated border
- Mirrored border
- Mirrored border with replication
- Border in memory
- Mixed borders

Constant Border

This type of border corresponds to the `ippBorderConst` value in the `IppiBorderType` enumerator. When using a constant border, values for all border pixels are set to the constant value that you specify in the `borderValue` parameter. In the figure below, this constant value is marked as \( V \). Squares marked in red correspond to pixels copied from the source image ROI.
Replicated Border

This type of border corresponds to the ippBorderRepl value in the IppiBorderType enumerator. When using a replicated border, values for border pixels are obtained from the source image boundary pixels, as shown in the figure below. Squares marked in red correspond to pixels copied from the source image ROI. Squares with green values correspond to border pixels, which are replicated from the boundary pixels of the source image.

Mirrored Border

This type of border corresponds to the ippBorderMirror value in the IppiBorderType enumerator. When using a mirrored border, values for border pixels are obtained from the source image boundary pixels, as shown in the figure below. Squares marked in red correspond to pixels copied from the source image ROI. Squares with green values correspond to border pixels, which are mirrored from the source image pixels.
Mirrored Border with Replication

This type of border corresponds to the `ippBorderMirrorR` value in the `IppiBorderType` enumerator. When using a mirrored border with replication, values for border pixels are obtained from the source image boundary pixels, as shown in the figure below. Squares marked in red correspond to pixels copied from the source image ROI. Squares with green values correspond to border pixels, which are mirrored from the source image pixels. The difference of this border type from the mirrored border is that the anchor cell value is replicated to the border pixels.

Border in Memory

This type of border corresponds to the `ippBorderInMem` value and its flags combinations in the `IppiBorderType` enumerator. Use this border type if the ROI does not cover internal border pixels of the source image. In this case, values for border pixels are obtained from the source image pixels in memory. In the figure below, squares marked in red correspond to pixels copied from the source image ROI. Squares with black values correspond to source image pixels in memory.
Several Intel IPP filters operate in two or more stages. For example, the ippiMorphOpenBorder function performs filtering by applying the Erode and Dilate filters sequentially. You should note the following when setting borders for multistage filters:

- If you set the ippBorderInMem value or its flags combinations, the function tries to access pixels outside of image borders to get border pixels for each filtering stage. For example, the ippiMorphOpenBorder function uses two stages and with 5x5 mask will access floor(5/2)*2=4 pixels in each direction across the current ROI.
- If you set ippBorderFirstStageInMem, the function tries to access floor(5/2)=2 pixels outside of the image borders to get pixels for the first stage of filtering. The second filter will use one of the following border types to reconstruct image borders: ippBorderRepl, ippBorderConst, ippBorderMirror, or ippBorderMirrorR. To specify the border type for the second and next stages, use the bitwise OR operation between one of the listed above border types and ippBorderFirstStageInMem.

**Mixed Borders**

You can use mixed borders by using a bitwise OR operation between one of the ippBorderRepl, ippBorderConst, ippBorderMirror, or ippBorderMirrorR types and any of the following border types: ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight, or ippBorderFirstStageInMem. In this case, values for border pixels are obtained from the source image pixels in memory in the direction specified by the flag.

The figure below demonstrates the use of the ippBorderConst with the ippBorderInMemTop and ippBorderInMemRight borders. Squares marked in red correspond to pixels copied from the source image, that is the source image ROI. As you can see from the figure, top and right border pixels are obtained from the source image pixels in memory, while the rest of the border pixels are set to the constant value $V$. 

![Image of binary matrix]
NOTE
The combination of ippBorderInMem and its flags always has priority over any other border flags or types. For example, if you specify ippBorderFirstStageInMem|ippBorderRepl|ippBorderInMemLeft, the left border will use InMem mode for each stage and other borders will use InMem for the first stage and replication for remaining stages.

The figure below demonstrates the use of the ippBorderConst with the ippBorderInMemTop, ippBorderInMemRight, and ippBorderFirstStageInMem flags for two-stage filtering with one pixel border for both stages.

- **First stage:** squares marked in red correspond to pixels copied from the source image, which is the source image ROI, and squares marked in blue correspond to ROI assigned to the first stage filter. As you can see from the figure, the first stage enlarges ROI for top and right sides to consume more memory and provide valid pixels for the second stage memory border.
- **Second stage:** red squares and blue pixels correspond to resulting pixels from the first stage filter. Blue pixels lie outside of the ROI providing border values for the second stage in top and right directions. Left and bottom border pixels use the constant value V in accordance with the border flags combination.

### First stage:

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</tbody>
</table>

Source Image ROI
First stage ROI
Source Image Pixels in Memory for both stages
Source Image Pixels in Memory for first stage only

Constant Value

Pixels in Memory from the first stage
Filters with Borders

This section describes Intel® IPP filtering functions that automatically create a required border and define appropriate pixel values.

See Also
Regions of Interest in Intel IPP
Borders in Neighborhood Operations

FilterBilateral
Performs bilateral filtering of an image.

Syntax

Case 1: Operation on pixel-order data

IppStatus ippiFilterBilateral_<mod>(const Ipp<srcdatatype>* pSrc, int srcStep, Ipp<dstdatatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiBorderType borderType, const Ipp<datatype> pBorderValue[1], const IppFilterBilateralSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C1R 32f_C1R 64f_C1R

IppStatus ippiFilterBilateral_<mod>(const Ipp<srcdatatype>* pSrc, int srcStep, Ipp<dstdatatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiBorderType borderType, const Ipp<datatype> pBorderValue[3], const IppFilterBilateralSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C3R 32f_C3R 64f_C3R

Case 2: Operation on planar data

IppStatus ippiFilterBilateral_<mod>(const Ipp<srcdatatype>* pSrc[3], int srcStep[3], Ipp<dstdatatype>* pDst[3], int dstStep[3], IppiSize dstRoiSize, IppiBorderType borderType, const Ipp<datatype> pBorderValue[3], const IppFilterBilateralSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_P3R 32f_P3R 64f_P3R
Case 3: Operation on pixel-order data with platform-aware functions

IppStatus ippiFilterBilateral_<mod>(const Ipp<srcdatatype>* pSrc, IppSizeL srcStep, Ipp<srcdatatype>* pDst, IppSizeL dstStep, IppSizeL dstRoiSize, IppiBorderType borderType, const Ipp<datatype> pBorderValue[1], const IppiFilterBilateralSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C1R_L 32f_C1R_L 64f_C1R_L

IppStatus ippiFilterBilateral_<mod>(const Ipp<srcdatatype>* pSrc, IppSizeL srcStep, Ipp<srcdatatype>* pDst, IppSizeL dstStep, IppSizeL dstRoiSize, IppiBorderType borderType, const Ipp<datatype> pBorderValue[3], const IppiFilterBilateralSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C3R_L 32f_C3R_L 64f_C3R_L

Case 4: Operation on planar data with platform-aware functions

IppStatus ippiFilterBilateral_<mod>(const Ipp<srcdatatype>* pSrc[3], IppSizeL srcStep[3], Ipp<srcdatatype>* pDst[3], IppSizeL dstStep[3], IppSizeL dstRoiSize, IppiBorderType borderType, const Ipp<datatype> pBorderValue[3], const IppiFilterBilateralSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_P3R_L 32f_P3R_L 64f_P3R_L

Case 5: Operation on pixel-order data with Threading Layer (TL) functions based on the Platform Aware API

IppStatus ippiFilterBilateral_<mod>(const Ipp<srcdatatype>* pSrc, IppSizeL srcStep, Ipp<srcdatatype>* pDst, IppSizeL dstStep, IppSizeL dstRoiSize, IppiBorderType borderType, const Ipp<datatype> pBorderValue[1], const IppiFilterBilateralSpec_LT* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C1R_LT 32f_C1R_LT 64f_C1R_LT

IppStatus ippiFilterBilateral_<mod>(const Ipp<srcdatatype>* pSrc, IppSizeL srcStep, Ipp<srcdatatype>* pDst, IppSizeL dstStep, IppSizeL dstRoiSize, IppiBorderType borderType, const Ipp<datatype> pBorderValue[3], const IppiFilterBilateralSpec_LT* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C3R_LT 32f_C3R_LT 64f_C3R_LT
Case 6: Operation on planar data with Threading Layer (TL) functions based on the Platform Aware API

IppStatus ippiFilterBilateral_<mod>(const Ipp<srcdatatype>* pSrc[3], IppSizeL srcStep[3], Ipp<dstdatatype>* pDst[3], IppSizeL dstStep[3], IppiBorderType borderType, const Ipp<datatype> pBorderValue[3], const IppFilterBilateralSpec_LT* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u_P3R_LT 32f_P3R_LT 64f_P3R_LT

Case 7: Operation on pixel-order data with Threading Layer (TL) functions based on the Classic API

IppStatus ippiFilterBilateral_<mod>(const Ipp<srcdatatype>* pSrc, int srcStep, Ipp<dstdatatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiBorderType borderType, const Ipp<datatype> pBorderValue[1], const IppFilterBilateralSpec_T* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u_C1R_T 32f_C1R_T 64f_C1R_T

IppStatus ippiFilterBilateral_<mod>(const Ipp<srcdatatype>* pSrc, int srcStep, Ipp<dstdatatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiBorderType borderType, const Ipp<datatype> pBorderValue[3], const IppFilterBilateralSpec_T* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u_C3R_T 32f_C3R_T 64f_C3R_T

Case 8: Operation on planar data with Threading Layer (TL) functions based on the Classic API

IppStatus ippiFilterBilateral_<mod>(const Ipp<srcdatatype>* pSrc[3], int srcStep[3], Ipp<dstdatatype>* pDst[3], int dstStep[3], IppiSize dstRoiSize, IppiBorderType borderType, const Ipp<datatype> pBorderValue[3], const IppFilterBilateralSpec_T* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u_P3R_T 32f_P3R_T 64f_P3R_T

Include Files
ippi.h
ippi_l.h
ippi_t1l.h

Domain Dependencies

Flavors declared in ippi.h:
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

pSrc
Pointer to the source image ROI.

srcStep
Distance, in bytes, between the starting points of consecutive lines in the source image.

pDst
Pointer to the destination image ROI.

dstStep
Distance, in bytes, between the starting points of consecutive lines in the destination image.

dstRoiSize
Size of the source and destination ROI in pixels.

borderType
Type of border. Possible values are:

ippBorderConst Values of all border pixels are set to constant.

ippBorderRepl Border is replicated from the edge pixels.

ippBorderInMem Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderRepl and ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight.

pBorderValue
Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

pSpec
Pointer to the bilateral context structure.

pBuffer
Pointer to the work buffer.

Description

This function applies the bilateral filter with a square kernel to the source image. The linear dimension of the kernel is defined in the initialization function FilterBilateralInit. The bilateral context structure contains the parameters of filtering.

Before using the ippiFilterBilateral function, compute the size of the bilateral context structure and the external buffer using the FilterBilateralGetBufferSize function and initialize the structure using the FilterBilateralInit function.

Return Values

ippStsNoErr Indicates no error.

ippStsNullPtrErr Indicates an error when pSrc, pDst, pSpec, or pBuffer is NULL.

ippStsSizeErr Indicates an error when dstRoiSize has a field with a zero or negative value.

ippStsContextMatchErr Indicates an error when the pSpec structure does not match the function.
Indicates an error when one of the step values is not divisible by 4 for floating-point images.

Indicates an error when `borderType` has an illegal value.

**See Also**
- Regions of Interest in Intel IPP
- User-defined Border Types

**FilterBilateralGetBufferSize** Computes the size of the bilateral context structure and the size of the work buffer for bilateral filtering with user-defined borders.

**FilterBilateralInit** Initializes the bilateral context structure.

**FilterBilateralGetBufferSize**

*Computes the size of the bilateral context structure and the size of the work buffer for bilateral filtering with user-defined borders.*

**Syntax**

```c
IppStatus ippiFilterBilateralGetBufferSize(IppiFilterBilateralType filter, IppSize dstRoiSize, int kernelWidthHeight, IppDataType dataType, int numChannels, IppiDistanceMethodType distMethodType, int* pSpecSize, int* pBufferSize);
```

**Platform-aware function**

```c
IppStatus ippiFilterBilateralGetBufferSize_L(IppiFilterBilateralType filter, IppSizeL dstRoiSize, IppSizeL kernelWidthHeight, IppDataType dataType, int numChannels, IppiDistanceMethodType distMethodType, IppSizeL* pSpecSize, IppSizeL* pBufferSize);
```

**Threading Layer (TL) function based on the Platform Aware API**

```c
IppStatus ippiFilterBilateralGetBufferSize_LT(IppiFilterBilateralType filter, IppSizeL dstRoiSize, IppSizeL kernelWidthHeight, IppDataType dataType, int numChannels, IppiDistanceMethodType distMethodType, IppSizeL* pSpecSize, IppSizeL* pBufferSize);
```

**Threading Layer (TL) function based on the Classic API**

```c
IppStatus ippiFilterBilateralGetBufferSize_T(IppiFilterBilateralType filter, IppSize dstRoiSize, int kernelWidthHeight, IppDataType dataType, int numChannels, IppiDistanceMethodType distMethodType, int* pSpecSize, int* pBufferSize);
```

**Include Files**

ippi.h
ippi_l.h
ippi_tl.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- `filter` Type of the bilateral filter. Possible value is `ippiFilterBilateralGauss` - Gaussian bilateral filter.
- `dstRoiSize` Size of the destination ROI in pixels.
kernelWidthHeight

Linear dimension of the square kernel. The value 1 corresponds to the distance between two adjacent pixels.

dataType

Data type of the source and destination images. Possible values are ipp8u, ipp32f, and ipp64f.

numChannels

Number of channels in the images.

distMethodType

Method of defining the differences in intensity between pixels. Depending on the number of channels in the image, possible value are:

<table>
<thead>
<tr>
<th>numChannels value</th>
<th>Possible distMethodType values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ippDistNormL1</td>
</tr>
<tr>
<td>3</td>
<td>ippDistNormL1, ippDistNormL2</td>
</tr>
</tbody>
</table>

pSpecSize

Pointer to the computed size of the specification structure.

pBufferSize

Pointer to the computed size of the external buffer.

Description

This function computes the size of the bilateral context structure and external work buffer for the FilterBilateral function. The results are stored in pSpecSize and pBufferSize.

Use the computed pBufferSize and pSpecSize values to allocate the memory using the ippMalloc or ippsMalloc functions. The allocated memory can be freed only by the ippFree or ippsFree functions, respectively. For more information about the memory allocation functions, refer to the "Support Functions" section of the Intel IPP Developer Reference, vol. 1.

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error.

ippStsNullPtrErr

Indicates an error when pSpecSize or pBufferSize is NULL.

ippStsSizeErr

Indicates an error when dstRoiSize has a field with a zero or negative value.

ippStsMaskSizeErr

Indicates an error when kernelWidthHeight is less than, or equal to zero.

ippStsNotSupportedModeErr

Indicates an error when the filter or distMethodType value is not supported.

ippStsDataTypeErr

Indicates an error when dataType has an illegal value.

ippStsNumChannelsErr

Indicates an error when numChannels has an illegal value.

See Also

FilterBilateral  Performs bilateral filtering of an image.

FilterBilateralInit  Initializes the bilateral context structure.

FilterBilateralAllInit

Initializes the bilateral context structure.
Syntax
IppStatus ippiFilterBilateralInit(IppiFilterBilateralType filter, IppiSize dstRoiSize, int kernelWidthHeight, IppDataType dataType, int numChannels, IppiDistanceMethodType distMethod, Ipp64f valSquareSigma, Ipp64f posSquareSigma, IppiFilterBilateralSpec* pSpec);

Platform-aware function
IppStatus ippiFilterBilateralInit_L(IppiFilterBilateralType filter, IppiSizeL dstRoiSize, IppSizeL kernelWidthHeight, IppDataType dataType, int numChannels, IppiDistanceMethodType distMethod, Ipp64f valSquareSigma, Ipp64f posSquareSigma, IppiFilterBilateralSpec* pSpec);

Threading Layer (TL) function based on the Platform Aware API
IppStatus ippiFilterBilateralInit_LT(IppiFilterBilateralType filter, IppiSizeL dstRoiSize, IppSizeL kernelWidthHeight, IppDataType dataType, int numChannels, IppiDistanceMethodType distMethod, Ipp64f valSquareSigma, Ipp64f posSquareSigma, IppiFilterBilateralSpec_LT* pSpec);

Threading Layer (TL) function based on the Classic API
IppStatus ippiFilterBilateralInit_T(IppiFilterBilateralType filter, IppiSize dstRoiSize, int kernelWidthHeight, IppDataType dataType, int numChannels, IppiDistanceMethodType distMethod, Ipp64f valSquareSigma, Ipp64f posSquareSigma, IppiFilterBilateralSpec_T* pSpec);

Include Files
ippi.h
ippi_l.h
ippi_tl.h

Domain Dependencies
Flavors declared in ippi.h:
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
filter
Type of the bilateral filter. Possible value is ippiFilterBilateralGauss - Gaussian bilateral filter.
dstRoiSize
Size of the destination ROI in pixels.
kernelWidthHeight
Linear dimension of the square kernel. The value 1 corresponds to the distance between two adjacent pixels.
dataType
Data type of the source and destination images. Possible values are ipp8u, ipp32f, and ipp64f.
umChannels
Number of channels in the images.
distMethod
Method of defining the differences in intensity between pixels. Depending on the number of channels in the image, possible value are:

```
numChannels value  Possible distMethod values
```
valSquareSigma
Square of the range parameter, which controls smoothing based on the differences in intensity between pixels.

posSquareSigma
Square of the spatial parameter, which controls smoothing based on the geometric distance between pixels.

pSpec
Pointer to the bilateral context structure.

Description
This function initializes the bilateral context structure pSpecSize for bilateral filtering. Before using this function, compute the size of the context structure using the FilterBilateralGetBufferSize function.

The kernelWidthHeight parameter specifies the linear dimension of the square filter kernel. The value 1 corresponds to the distance between the centers of two adjacent pixels.

Coefficients of the bilateral filter kernel depend on their positions in the kernel and on the intensity value of the source image pixels lying in the kernel.

The value of the output pixel \( d \) is computed by the following formula:

\[
d = \frac{\sum_{i,j} w_{1ij} \cdot w_{2ij} \cdot v_{ij}}{\sum_{i,j} w_{1ij} \cdot w_{2ij}}
\]

For all indices \( i \) and \( j \) that fit within the square kernel

where
- \( v_{ij} \) is the value (or channel values) of a pixel in the kernel with coordinates \( i \) and \( j \)
- \( w_{1ij} = \text{Fun}(\text{valSquareSigma}, \text{Intensity Distance}(v_{ij}, v_{00})) \)
- \( w_{2ij} = \text{Fun}(\text{posSquareSigma}, \text{Geometric Distance}(v_{ij}, v_{00}) = \sqrt{i^2 + j^2}) \)

\( \text{Fun}(S, I) = \exp(-I^2 / 2S) \)

where
- \( S \) is \( \text{valSquareSigma} \) or \( \text{posSquareSigma} \)
- \( I \) is the difference between pixel values or position

Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error.

ippStsNullPtrErr
Indicates an error when \( pSpec \) is NULL.

ippStsSizeErr
Indicates an error when \( dstRoiSize \) has a field with a zero or negative value.
ippStsMaskSizeErr
Indicates an error when `kernelWidthHeight` is less than, or equal to zero.

ippStsNotSupportedModeErr
Indicates an error when the `filter` or `distMethod` value is not supported.

ippStsBadArgErr
Indicates an error when `valSquareSigma` or `posSquareSigma` is less than, or equal to zero.

ippStsNumChannelsErr
Indicates an error when `numChannels` has an illegal value.

See Also
Structures and Enumerators for Platform-Aware Functions
FilterBilateralGetBufferSize Computes the size of the bilateral context structure and the size of the work buffer for bilateral filtering with user-defined borders.
FilterBilateral Performs bilateral filtering of an image.

FilterBilateralBorderGetBufferSize
Computes the size of the bilateral context structure and the size of the work buffer for bilateral filtering with user-defined borders.

Syntax
Processing images of 32-bit sizes
IppStatus ippiFilterBilateralBorderGetBufferSize(IppiFilterBilateralType filter, IppiSize dstRoiSize, int radius, IppDataType dataType, int numChannels, IppiDistanceMethodType distMethodType, int* pSpecSize, int* pBufferSize);

Platform-aware function
IppStatus ippiFilterBilateralBorderGetBufferSize_L(IppiFilterBilateralType filter, IppiSizeL dstRoiSize, int radius, IppDataType dataType, int numChannels, IppiDistanceMethodType distMethodType, IppSizeL* pSpecSize, IppSizeL* pBufferSize);

Threading layer function
IppStatus ippiFilterBilateralBorderGetBufferSize_LT(IppiFilterBilateralType filter, IppiSizeL dstRoiSize, int radius, IppDataType dataType, int numChannels, IppiDistanceMethodType distMethodType, IppSizeL* pSpecSize, IppSizeL* pBufferSize);

Include Files
ippi.h

Flavors with the _LT suffix: ippi_tl.h
Flavors with the _L suffix: ippi_l.h

Domain Dependencies
Flavors declared in ippi.h:
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:
**Parameters**

- **filter**
  Type of the bilateral filter. Possible value is `ippiFilterBilateralGauss` - Gaussian bilateral filter.

- **dstRoiSize**
  Size of the destination ROI in pixels.

- **radius**
  Radius of the round kernel. The radius value equal to 1 corresponds to distance between the closest pixels.

- **dataType**
  Data type of the source and destination images. Possible values are `ipp8u` and `ipp32f`.

- **numChannels**
  Number of channels in the images.

- **distMethodType**
  Method of defining intensive distance between pixels. Possible value is `ippDistNormL1`.

- **pSpecSize**
  Pointer to the computed size of the specification structure.

- **pBufferSize**
  Pointer to the computed size of the external buffer.

**Description**

This function computes the size of the bilateral context structure and external work buffer for the `FilterBilateralBorder` function. The results are stored in `pSpecSize` and `pBufferSize`. Use the computed `pBufferSize` and `pSpecSize` values to allocate the memory using the `ippMalloc` or `ippsMalloc` functions. The allocated memory can be freed only by the `ippFree` or `ippsFree` functions, respectively. For more information about the memory allocation functions, refer to the "Support Functions" section of the *Intel IPP Developer Reference, vol. 1*.

For an example on how to use this function, refer to the example provided with the `FilterBilateralBorder` function description.

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error.

- **ippStsNullPtrErr**
  Indicates an error when `pSpecSize` or `pBufferSize` is NULL.

- **ippStsSizeErr**
  Indicates an error when `dstRoiSize` has a field with a zero or negative value.

- **ippStsMaskSizeErr**
  Indicates an error when `radius` is less than, or equal to zero.

- **ippStsNotSupportedModeErr**
  Indicates an error when the `filter` or `distMethodType` value is not supported.

- **ippStsDataTypeErr**
  Indicates an error when `dataType` has an illegal value.

- **ippStsNumChannelsErr**
  Indicates an error when `numChannels` has an illegal value.

**See Also**

- *FilterBilateralBorder* Performs bilateral filtering of an image.

- *FilterBilateralBorderInit* Initializes the bilateral context structure.
**Syntax**

```c
IppStatus ippiFilterBilateralBorderInit(IppFilterBilateralType filter, IppiSize dstRoiSize, int radius, IppDataType dataType, int numChannels, IppiDistanceMethodType distMethod, Ipp32f valSquareSigma, Ipp32f posSquareSigma, IppFilterBilateralSpec* pSpec);
```

**Platform-aware function**

```c
IppStatus ippiFilterBilateralBorderInit_L(IppFilterBilateralType filter, IppiSizeL dstRoiSize, int radius, IppDataType dataType, int numChannels, IppiDistanceMethodType distMethod, Ipp32f valSquareSigma, Ipp32f posSquareSigma, IppFilterBilateralSpec* pSpec);
```

**Threading layer function**

```c
IppStatus ippiFilterBilateralBorderInit_LT(IppFilterBilateralType filter, IppiSizeL dstRoiSize, int radius, IppDataType dataType, int numChannels, IppiDistanceMethodType distMethod, Ipp32f valSquareSigma, Ipp32f posSquareSigma, IppFilterBilateralSpec_LT* pSpec);
```

**Include Files**

```c
ippi.h
```

- **Flavors with the _LT suffix:** ippi_tl.h
- **Flavors with the _L suffix:** ippi_l.h

**Domain Dependencies**

- **Flavors declared in ippi.h:**
  - **Headers:** ippcore.h, ippvm.h, ipps.h
  - **Libraries:** ippcore.lib, ippvm.lib, ipps.lib

- **Flavors declared in ippi_tl.h:**
  - **Libraries:** ippcore.lib, ippvm.lib, ipps.lib, ippcore_tl.lib, ippi_tl.lib

**Parameters**

- **filter**
  - Type of the bilateral filter. Possible value is `ippiFilterBilateralGauss` - Gaussian bilateral filter.
  - **Size of the destination ROI in pixels.**

- **dstRoiSize**
  - Radius of the round kernel. The radius value equal to 1 corresponds to distance between the closest pixels.

- **radius**
  - Data type of the source and destination images. Possible values are `ipp8u` and `ipp32f`.

- **dataType**
  - Number of channels in the images.

- **numChannels**
  - Method of defining intensive distance between pixels. Possible value is `ippDistNormL1`.

- **distMethod**
  - Square of the sigma for intensive distance between pixels.

- **valSquareSigma**
  - Square of the sigma for geometric distance between pixels.

- **posSquareSigma**
  - Pointer to the bilateral context structure.
Description
This function initializes the bilateral context structure `pSpecSize` for bilateral filtering. Before using this function, compute the size of the context structure using the `FilterBilateralBorderGetBufferSize` function.

The `radius` parameter specifies the radius of the round filter kernel. The radius value equal to 1 corresponds to the distance between centers of the closest pixels.

Coefficients of the bilateral filter kernel depend on their positions in the kernel and on the intensity value of the source image pixels lying in the kernel.

The value of the output pixel $d$ is computed by the following formula:

$$d = \frac{\sum_{i,j} w_{1_{ij}} \cdot w_{2_{ij}} \cdot v_{ij}}{\sum_{i,j} w_{1_{ij}} \cdot w_{2_{ij}}}$$

For all $i$ and $j$ that $i^2 + j^2 \leq radius^2$ (for central pixel of the kernel $i=0, j=0$)

where

- $v_{ij}$ is the value (or channel values) of a pixel in the kernel with coordinates $i$ and $j$
- $w_{1_{ij}} = \text{Fun}(\text{valSquareSigma}, \text{Intensity Distance}(v_{ij}, v_{00}))$
- $w_{2_{ij}} = \text{Fun}(\text{posSquareSigma}, \text{Geometric Distance}(v_{ij}, v_{00}) = \sqrt{i^2 + j^2})$

$$\text{Fun}(S, I) = \exp(-I^2/2*S)$$

where

- $S$ is `valSquareSigma` or `posSquareSigma`
- $I$ is the difference between pixel values or position

For an example on how to use this function, refer to the example provided with the `FilterBilateralBorder` function description.

Return Values

- `ippStsNoErr`: Indicates no error. Any other value indicates an error.
- `ippStsNullPtrErr`: Indicates an error when `pSpec` is NULL.
- `ippStsSizeErr`: Indicates an error when `dstRoiSize` has a field with a zero or negative value.
- `ippStsMaskSizeErr`: Indicates an error when `radius` is less than, or equal to zero.
- `ippStsNotSupportedModeErr`: Indicates an error when the `filter` or `distMethod` value is not supported.
- `ippStsBadArgErr`: Indicates an error when `valSquareSigma` or `posSquareSigma` is less than, or equal to zero.
See Also
FilterBilateralBorderGetBufferSize Computes the size of the bilateral context structure and the size of the work buffer for bilateral filtering with user-defined borders.
FilterBilateralBorder Performs bilateral filtering of an image.

FilterBilateralBorder
Performs bilateral filtering of an image.

Syntax
Processing images of 32-bit sizes
IppStatus ippiFilterBilateralBorder_<mod>(const Ipp<srcdatatype>* pSrc, int srcStep, Ipp<dstdatatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiBorderType borderType, Ipp<srcdatatype>* pBorderValue, IppiFilterBilateralSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

| 8u_C1R | 8u_C3R | 32f_C1R | 32f_C3R |

Platform-aware functions
IppStatus ippiFilterBilateralBorder_<mod>(const Ipp<srcdatatype>* pSrc, IppSizeL srcStep, Ipp<dstdatatype>* pDst, IppSizeL dstStep, IppSizeL dstRoiSize, IppiBorderType borderType, Ipp<srcdatatype>* pBorderValue, const IppiFilterBilateralSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

| 8u_C1R_L | 8u_C3R_L |

Threading layer functions
IppStatus ippiFilterBilateralBorder_<mod>(const Ipp<srcdatatype>* pSrc, IppSizeL srcStep, Ipp<dstdatatype>* pDst, IppSizeL dstStep, IppSizeL dstRoiSize, IppiBorderType borderType, Ipp<srcdatatype>* pBorderValue, IppiFilterBilateralSpec_LT* pSpec, Ipp8u* pBuffer);

Supported values for mod:

| 8u_C1R_L | 8u_C3R_L |

Include Files
ippi.h

Flavors with the _LT suffix: ippi_tl.h
Flavors with the _L suffix: ippi_l.h

Domain Dependencies
Flavors declared in ippi.h:

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:

Parameters

pSrc  
Pointer to the source image ROI.

srcStep  
Distance, in bytes, between the starting points of consecutive lines in the source image.

pDst  
Pointer to the destination image ROI.

dstStep  
Distance, in bytes, between the starting points of consecutive lines in the destination image.

dstRoiSize  
Size of the source and destination ROI in pixels.

borderType  
Type of border. Possible values are:

ippBorderConst  Values of all border pixels are set to constant.

ippBorderRepl  Border is replicated from the edge pixels.

ippBorderInMem  Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderRepl and ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight.

pBorderValue  
Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

pSpec  
Pointer to the bilateral context structure.

pBuffer  
Pointer to the work buffer.

Description

This function applies the bilateral filter with the round kernel to the source image. The radius of the kernel is defined in the corresponding initialization function FilterBilateralBorderInit. The bilateral context structure contains the parameters of filtering.

Before using the ippiFilterBilateralBorder function, compute the size of the bilateral context structure and the external buffer using the FilterBilateralBorderGetBufferSize function and initialize the structure using the FilterBilateralBorderInit function.

Return Values

ippiStsNoErr  Indicates no error.

ippiStsNullPtrErr  Indicates an error when pSrc, pDst, pSpec, or pBuffer is NULL.

ippiStsSizeErr  Indicates an error when dstRoiSize has a field with a zero or negative value.
### FilterBoxBorderGetBufferSize

*Computes the size of the external buffer for the FilterBoxBorder function.*

**Syntax**

```c
IppStatus ippiFilterBoxBorderGetBufferSize (IppiSize roiSize, IppiSize maskSize, IppDataType dataType, int numChannels, int* pBufferSize);
```

**Include Files**

`ippi.h`

**Domain Dependencies**

*Headers:* `ippicore.h`, `ippvm.h`, `ipps.h`

*Libraries:* `ippicore.lib`, `ippvm.lib`, `ipps.lib`

**Parameters**

- `roiSize`: Maximum size of the destination image ROI.
- `maskSize`: Size of the filter mask, in pixels.
- `dataType`: Data type of the image. Possible values are `ipp8u`, `ipp16u`, `ipp16s`, or `ipp32f`.
- `numChannels`: Number of channels in the image. Possible values are 1, 3, or 4.
- `pBufferSize`: Pointer to the size of the external work buffer.

**Description**

The `ippiFilterBoxBorderGetBufferSize` function computes the size, in bytes, of the external work buffer needed for the `ippiFilterBoxBorder` function. The result is stored in the `pBufferSize` parameter.

For an example on how to use this function, see the code example provided with the `ippiFilterBoxBorder` function description.
Return Values

ippStsNoErr  Indicates no error.
ippStsSizeErr Indicates an error when roiSize is negative, or equal to zero.
ippStsMaskSizeErr Indicates an error when mask has an illegal value.
ippStsDataTypeErr Indicates an error when dataType has an illegal value.
ippStsNumChannelsError Indicates an error when numChannels has an illegal value.

See Also
FilterBoxBorder  Blurs an image using a simple box filter.

FilterBoxBorder
Blurs an image using a simple box filter.

Syntax
IppStatus ippiFilterBoxBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType border, const Ipp<datatype>* borderValue, Ipp8u* pBuffer);

Supported values for mod:

8u_C1R  16u_C1R  16s_C1R  32f_C1R

IppStatus ippiFilterBoxBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType border, const Ipp<datatype> borderValue[3], Ipp8u* pBuffer);

Supported values for mod:

8u_C3R  16u_C3R  16s_C3R  32f_C3R
16u_C4R  16s_C4R
16u_AC4R  16s_AC4R

IppStatus ippiFilterBoxBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType border, const Ipp<datatype> borderValue[4], Ipp8u* pBuffer);

Supported values for mod:

8u_C4R  32f_C4R
8u_AC4R  32f_AC4R

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

- **pSrc**: Pointer to the source image.
- **srcStep**: Distance, in bytes, between the starting points of consecutive lines in the source image.
- **pDst**: Pointer to the destination image.
- **dstStep**: Distance, in bytes, between the starting points of consecutive lines in the destination image.
- **roiSize**: Size of the destination ROI in pixels.
- **maskSize**: Size of the mask in pixels.
- **border**: Type of border. Possible values are:
  - ippBorderConst: Values of all border pixels are set to constant.
  - ippBorderRepl: Border is replicated from the edge pixels.
  - ippBorderInMem: Border is obtained from the source image pixels in memory.
  - ippBorderMirror: Border pixels are mirrored from the source image boundary pixels.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderRepl and ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight.

- **borderValue**: Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.
- **pBuffer**: Pointer to the work buffer.

Description

Before using this function, you need to compute the size of the work buffer **pBuffer** using the ippiFilterBoxBorderGetBufferSize function.

This function operates with ROI.

This function sets each pixel in the destination image as the average of all pixels of the source image in the rectangular neighborhood of size maskSize with the anchor cell at that pixel. This has the effect of smoothing or blurring the input image. To ensure valid operation when image boundary pixels are processed, the application must correctly define additional border pixels. If **pSrc** is equal to **pDst**, ippiFilterBoxBorder operates as an in-place function.

Return Values

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error when **pSrc** or **pDst** is NULL.
Indicates an error if `roiSize` has a field with zero or negative value.

Indicates an error if `mask` has an illegal value.

Indicates an error when `border` has an illegal value.

**Example**

To better understand usage of this function, refer to the `FilterBoxBorder.c` example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples:

**FilterBox**

*Blurs an image using a simple box filter.*

**Syntax**

```c
IppStatus ippiFilterBox_64f_C1R(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiPoint anchor);
```

**Include Files**

`ippi.h`

**Domain Dependencies**

- **Headers:** `ippcore.h`, `ippvm.h`, `ipps.h`
- **Libraries:** `ippcore.lib`, `ippvm.lib`, `ipps.lib`

**Parameters**

- `pSrc` Pointer to the source image ROI.
- `srcStep` Distance in bytes between starts of consecutive lines in the source image.
- `pDst` Pointer to the destination image ROI.
- `dstStep` Distance in bytes between starts of consecutive lines in the destination image.
- `dstRoiSize` Size of the destination ROI in pixels.
- `maskSize` Size of the mask in pixels.
- `anchor` Anchor cell specifying the mask alignment with respect to the position of the input pixel.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function sets each pixel in the destination image as the average of all the input image pixels in the rectangular neighborhood of size `maskSize` with the anchor cell at that pixel. This has the effect of smoothing or blurring on the input image. To ensure valid operation when image boundary pixels are processed, the application must correctly define additional border pixels (see Borders in Neighborhood Operations).
Return Values

ippiStsNoErr  Indicates no error. Any other value indicates an error or a warning.
ippiStsNullPtrErr  Indicates an error if pSrc, pDst, or pSrcDst is NULL.
ippiStsSizeErr  Indicates an error if dstRoiSize has a field with zero or negative value.
ippiStsStepErr  Indicates an error if srcStep or dstStep has a zero or negative value.
ippiStsMaskSizeErr  Indicates an error if maskSize has a field with zero or negative value.
ippiStsAnchorErr  Indicates an error if anchor is outside the mask size.
ippiStsMemAllocErr  Indicates a memory allocation error.

FilterGaussianBorder
Performs Gaussian filtering of an image with user-defined borders.

Syntax

IppStatus ippiFilterGaussianBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, Ipp<datatype> borderValue, IppFilterGaussianSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C1R  16u_C1R  16s_C1R  32f_C1R

IppStatus ippiFilterGaussianBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, Ipp<datatype> borderValue[3], IppFilterGaussianSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C3R  16u_C3R  16s_C3R  32f_C3R

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc  Pointer to the source image ROI.
srcStep  Distance, in bytes, between the starting points of consecutive lines in the source image.
pDst  Pointer to the destination image ROI.
**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function applies the Gaussian filter to the source image ROI `pSrc`. The kernel of the Gaussian filter is the matrix of size `kernelSize`x`kernelSize` with the standard deviation `sigma`. The values of the Gaussian kernel elements are computed by the FilterGaussianInit function. Elements of the kernel are normalized. The anchor cell is the center of the kernel.

Before using the `ippiFilterGaussianBorder` function, compute the size of the Gaussian specification structure and the external buffer using the FilterGaussianGetBufferSize function and initialize the structure using the FilterGaussianInit function.

**Return Values**

- `ippStsNoErr`: Indicates no error.
- `ippStsNullPtrErr`: Indicates an error when one of the specified pointers is NULL.
- `ippStsSizeErr`: Indicates an error when `roiSize` has a field with a zero or negative value.
- `ippStsStepErr`: Indicates an error when `srcStep` or `dstStep` is less than `roiSize.width*<pixelSize>`.
- `ippStsNotEvenStepErr`: Indicates an error when one of the step values is not divisible by `sizeof(Ipp<dataType>)`.
- `ippStsBorderErr`: Indicates an error when `borderType` has an illegal value.
- `ippStsBadArgErr`: Indicates an error when `kernelSize` is even, or less than 3.

**Example**

To better understand usage of this function, refer to the FilterGaussianBorder.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

**See Also**

- Regions of Interest in Intel IPP
- User-defined Border Types
- FilterGaussianGetBufferSize: Computes the size of the Gaussian specification structure and the size of the external work buffer for Gaussian filtering with user-defined borders.
- FilterGaussianInit: Initializes the Gaussian context structure.

**SumWindow**

Sums pixel values in a rectangular area applied to an image.
Syntax

IppStatus ippiSumWindow_8u32s_C1R(const Ipp8u* pSrc, int srcStep, Ipp32s* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType BorderType, const Ipp8u* borderValue, Ipp8u* pBuffer);

IppStatus ippiSumWindow_8u32s_C3R(const Ipp8u* pSrc, int srcStep, Ipp32s* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType BorderType, const Ipp8u* borderValue, Ipp8u* pBuffer);

IppStatus ippiSumWindow_8u32s_C4R(const Ipp8u* pSrc, int srcStep, Ipp32s* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType BorderType, const Ipp8u* borderValue, Ipp8u* pBuffer);

IppStatus ippiSumWindow_8u32s_AC4R(const Ipp8u* pSrc, int srcStep, Ipp32s* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType BorderType, const Ipp8u* borderValue, Ipp8u* pBuffer);

IppStatus ippiSumWindow_16s32f_C1R(const Ipp16s* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType BorderType, const Ipp16s* borderValue, Ipp8u* pBuffer);

IppStatus ippiSumWindow_16s32f_C3R(const Ipp16s* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType BorderType, const Ipp16s* borderValue, Ipp8u* pBuffer);

IppStatus ippiSumWindow_16s32f_C4R(const Ipp16s* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType BorderType, const Ipp16s* borderValue, Ipp8u* pBuffer);

IppStatus ippiSumWindow_16s32f_AC4R(const Ipp16s* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType BorderType, const Ipp16s* borderValue, Ipp8u* pBuffer);

IppStatus ippiSumWindow_16u32f_C1R(const Ipp16u* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType BorderType, const Ipp16u* borderValue, Ipp8u* pBuffer);

IppStatus ippiSumWindow_16u32f_C3R(const Ipp16u* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType BorderType, const Ipp16u* borderValue, Ipp8u* pBuffer);

IppStatus ippiSumWindow_16u32f_C4R(const Ipp16u* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType BorderType, const Ipp16u* borderValue, Ipp8u* pBuffer);

IppStatus ippiSumWindow_16u32f_AC4R(const Ipp16u* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType BorderType, const Ipp16u* borderValue, Ipp8u* pBuffer);

IppStatus ippiSumWindow_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType BorderType, const Ipp32f* borderValue, Ipp8u* pBuffer);

IppStatus ippiSumWindow_32f_C3R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType BorderType, const Ipp32f* borderValue, Ipp8u* pBuffer);

IppStatus ippiSumWindow_32f_C4R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType BorderType, const Ipp32f* borderValue, Ipp8u* pBuffer);
IppStatus ippiSumWindow_32f_AC4R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, IppiBorderType BorderType, const Ipp32f* borderValue, Ipp8u* pBuffer);  

Include Files  
ippi.h  

Domain Dependencies  
Headers: ippcore.h, ippvm.h, ipps.h  
Libraries: ippcore.lib, ippvm.lib, ipps.lib  

Parameters  
pSrc  
Pointer to the source image ROI.  
srcStep  
Distance in bytes between the starting points of consecutive lines in the source image.  
pDst  
Pointer to the destination image ROI.  
dstStep  
Distance in bytes between the starting points of consecutive lines in the destination image.  
roiSize  
Size of the destination ROI in pixels.  
maskSize  
Size of the mask in pixels.  
BorderType  
Type of border. Possible values are:  
  ippBorderConst  
Values of all border pixels are set to constant.  
  ippBorderRepl  
Border is replicated from the edge pixels.  
  ippBorderInMem  
Border is obtained from the source image pixels in memory.  
  ippBorderMirror  
Border pixels are mirrored from the source image boundary pixels.  

Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, ippBorderMirror, and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.  

borderValue  
Constant value to assign to border pixels. This parameter is applicable only to the ippBorderConst border type.  

pBuffer  
Pointer to the work buffer.  

Description  
Before using this function, you need to compute the size of the work buffer pBuffer using the SumWindowGetBufferSize function.  
This function operates with ROI (see Regions of Interest in Intel IPP).
This function sets each pixel in the destination image ROI \( p_{Dst} \) to the sum of all the source image pixels in the rectangular neighborhood of size \( maskSize \) with the anchor cell at the corresponding pixel in the source image ROI \( p_{Src} \). To ensure valid operation while processing the image boundary pixels, the application must correctly define additional border pixels (see Borders in Neighborhood Operations).

**Return Values**

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error or a warning.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error if ( p_{Src} ) or ( p_{Dst} ) is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error if ( roiSize ) has a field with a zero or negative value.</td>
</tr>
<tr>
<td>ippStsMaskSizeErr</td>
<td>Indicates an error if ( maskSize ) has a field with a zero or negative value.</td>
</tr>
<tr>
<td>ippStsBorderErr</td>
<td>Indicates an error if ( BorderType ) has an illegal value.</td>
</tr>
</tbody>
</table>

**SumWindowGetBufferSize**

*Computes the size of the external buffer for the SumWindow function.*

**Syntax**

```c
IppStatus ippiSumWindowGetBufferSize(IppiSize roiSize, IppiSize maskSize, IppDataType dataType, int numChannels, int* pBufferSize);
```

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- \( roiSize \)       Maximum size of the destination ROI in pixels.
- \( maskSize \)       Size of the filter mask in pixels.
- \( dataType \)       Data type of the image. Possible values are: ipp8u, ipp16s, ipp16u, and ipp32f
- \( numChannels \)    Number of channels in the image. Possible values are 1, 3, and 4.
- \( pBufferSize \)    Pointer to the size, in bytes, of the external work buffer.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function computes the size, in bytes, of the external work buffer for the ippiSumWindow function. The result is stored in the \( pBufferSize \) parameter.
Return Values

ippStsNoErr    Indicates no error. Any other value indicates an error or a warning.
ippStsSizeErr  Indicates an error if roiSize has a field with a zero or negative value.
ippStsMaskSizeErr  Indicates an error if maskSize has an illegal value.
ippStsDataTypeErr  Indicates an error if dataType has an illegal value.
ippStsNumChannelsError  Indicates an error if numChannels has an illegal value.

SumWindowRow

Sums pixel values in the row mask applied to the image.

Syntax

IppStatus ippiSumWindowRow_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize dstRoiSize, int maskSize, int anchor);

Supported values for mod:

<table>
<thead>
<tr>
<th>srcDatatype</th>
<th>dstDatatype</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u32f_C1R</td>
<td>16u32f_C1R</td>
</tr>
<tr>
<td>8u32f_C3R</td>
<td>16u32f_C3R</td>
</tr>
<tr>
<td>8u32f_C4R</td>
<td>16u32f_C4R</td>
</tr>
<tr>
<td>16u32f_C1R</td>
<td>16s32f_C1R</td>
</tr>
<tr>
<td>16u32f_C3R</td>
<td>16s32f_C3R</td>
</tr>
<tr>
<td>16u32f_C4R</td>
<td>16s32f_C4R</td>
</tr>
</tbody>
</table>

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc  Pointer to the source image ROI.
srcStep  Distance in bytes between starts of consecutive lines in the source image.

pDst  Pointer to the destination image ROI.
dstStep  Distance in bytes between starts of consecutive lines in the destination image.
dstRoiSize  Size of the destination ROI in pixels.
maskSize  Size of the horizontal row mask in pixels.
anchor  Anchor cell specifying the row mask alignment with respect to the position of the input pixel.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function sets each pixel in the destination image ROI \( p_{Dst} \) as the sum of all the source image pixels in the horizontal row mask of size \( maskSize \) with the anchor cell \( anchor \) at the corresponding pixel in the source image ROI \( p_{Src} \). To ensure valid operation when image boundary pixels are processed, the application must correctly define additional border pixels (see Borders in Neighborhood Operations).

**Return Values**

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error if \( p_{Src}, p_{Dst} \) is NULL.
- ippStsSizeErr: Indicates an error if \( dstRoiSize \) has a field with a zero or negative value.
- ippStsMaskSizeErr: Indicates an error if \( maskSize \) has a field with a zero or negative value.
- ippStsAnchorErr: Indicates an error if \( anchor \) is outside the mask size.
- ippStsMemAllocErr: Indicates a memory allocation error.

**SumWindowColumn**

Sums pixel values in the column mask applied to the image.

**Syntax**

```c
IppStatus ippiSumWindowColumn_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize dstRoiSize, int maskSize, int anchor);
```

Supported values for \( \text{mod} \):

- 8u32f_C1R
- 16u32f_C1R
- 16s32f_C1R
- 8u32f_C3R
- 16u32f_C3R
- 16s32f_C3R
- 8u32f_C4R
- 16u32f_C4R
- 16s32f_C4R

**Include Files**

ippi.h

**Domain Dependencies**

- Headers: ippcore.h, ippvm.h, ipps.h
- Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- \( p_{Src} \): Pointer to the source image ROI.
- \( srcStep \): Distance in bytes between starts of consecutive lines in the source image.
- \( p_{Dst} \): Pointer to the destination image ROI.
- \( dstStep \): Distance in bytes between starts of consecutive lines in the destination image.
- \( dstRoiSize \): Size of the destination ROI in pixels.
maskSize

Size of the vertical column mask in pixels.

anchor

Anchor cell specifying the column mask alignment with respect to the position of the input pixel.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function sets each pixel in the destination image ROI pDst as the sum of all the source image pixels in the vertical column mask of size maskSize with the anchor cell anchor at the corresponding pixel in the source image ROI pSrc. To ensure valid operation when image boundary pixels are processed, the application must correctly define additional border pixels (see Borders in Neighborhood Operations).

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr

Indicates an error if pSrc, pDst is NULL.

ippStsSizeErr

Indicates an error if dstRoiSize has a field with a zero or negative value.

ippStsMaskSizeErr

Indicates an error if maskSize has a field with a zero or negative value.

ippStsAnchorErr

Indicates an error if anchor is outside the mask size.

ippStsMemAllocErr

Indicates a memory allocation error.

FilterMaxBorderGetBufferSize, FilterMinBorderGetBufferSize

Compute the size of the work buffer for the maximum/minimum filter.

Syntax

IppStatus ippiFilterMaxBorderGetBufferSize(IppiSize dstRoiSize, IppiSize maskSize, IppDataType dataType, int numChannels, int* pBufferSize);

IppStatus ippiFilterMinBorderGetBufferSize(IppiSize dstRoiSize, IppiSize maskSize, IppDataType dataType, int numChannels, int* pBufferSize);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

dstRoiSize

Size of the destination ROI, in pixels.

maskSize

Size of the filter kernel.

dataType

Data type of the source and destination images.
numChannels | Number of channels in the image. Possible values are 1, 3, or 4.

pBufferSize | Pointer to the size, in bytes, of the external buffer.

Description
The ippiFilterMaxBorderGetBufferSize and ippiFilterMinBorderGetBufferSize functions compute the size, in bytes, of the external work buffer for the ippiFilterMaxBorder and ippiFilterMinBorder functions, respectively. The result is stored in the pBufferSize parameter.

Return Values
- ippStsNoErr: Indicates no error. Any other value indicates an error.
- ippStsNullPtrErr: Indicates an error when pBufferSize is NULL.
- ippStsSizeErr: Indicates an error when dstRoiSize has a field with a zero or negative value.
- ippStsMaskSizeErr: Indicates an error when maskSize is less than, or equal to zero.
- ippStsDataTypeErr: Indicates an error when dataType has an illegal value.
- ippStsNumChannelErr: Indicates an error when numChannels has an illegal value.

See Also
FilterMaxBorder, FilterMinBorder  Filter an image using the maximum/minimum filter.

FilterMaxBorder, FilterMinBorder
Filter an image using the maximum/minimum filter.

Syntax
Case 1: Operating on one-channel data
IppStatus ippiFilterMaxBorder_8u_C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, Ipp8u borderValue, Ipp8u* pBuffer);
IppStatus ippiFilterMaxBorder_16s_C1R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, Ipp16s borderValue, Ipp8u* pBuffer);
IppStatus ippiFilterMaxBorder_16u_C1R(const Ipp16u* pSrc, int srcStep, Ipp16u* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, Ipp16u borderValue, Ipp8u* pBuffer);
IppStatus ippiFilterMaxBorder_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, Ipp32f borderValue, Ipp8u* pBuffer);
IppStatus ippiFilterMinBorder_8u_C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, Ipp8u borderValue, Ipp8u* pBuffer);
IppStatus ippiFilterMinBorder_16s_C1R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, Ipp16s borderValue, Ipp8u* pBuffer);
Case 2: Operating on multi-channel data

IppStatusippiFilterMaxBorder_16u_C1R(const Ipp16u* pSrc, int srcStep, Ipp16u* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp8u* pBuffer);

IppStatusippiFilterMaxBorder_16s_C1R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp16u* pBuffer);

IppStatusippiFilterMaxBorder_8u_C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp8u* pBuffer);

IppStatusippiFilterMaxBorder_16u_C3R(const Ipp16u* pSrc, int srcStep, Ipp16u* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp16u* pBuffer);

IppStatusippiFilterMaxBorder_32f_C3R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp32f* pBuffer);

IppStatusippiFilterMaxBorder_8u_C4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp8u* pBuffer);

IppStatusippiFilterMaxBorder_16u_C3R(const Ipp16u* pSrc, int srcStep, Ipp16u* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp16u* pBuffer);

IppStatusippiFilterMaxBorder_16s_C3R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp16s* pBuffer);

IppStatusippiFilterMaxBorder_32f_C4R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp32f* pBuffer);

IppStatusippiFilterMaxBorder_8u_C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp8u* pBuffer);

IppStatusippiFilterMaxBorder_16s_C3R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp16s* pBuffer);

IppStatusippiFilterMaxBorder_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp32f* pBuffer);

IppStatusippiFilterMaxBorder_8u_C4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp8u* pBuffer);

IppStatusippiFilterMaxBorder_16u_C4R(const Ipp16u* pSrc, int srcStep, Ipp16u* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp16u* pBuffer);

IppStatusippiFilterMaxBorder_16s_C4R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp16s* pBuffer);

IppStatusippiFilterMaxBorder_32f_C4R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp32f* pBuffer);

IppStatusippiFilterMinBorder_8u_C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp8u* pBuffer);

IppStatusippiFilterMinBorder_16u_C3R(const Ipp16u* pSrc, int srcStep, Ipp16u* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp16u* pBuffer);

IppStatusippiFilterMinBorder_32f_C3R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp32f* pBuffer);

IppStatusippiFilterMinBorder_8u_C4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp8u* pBuffer);

IppStatusippiFilterMinBorder_16u_C4R(const Ipp16u* pSrc, int srcStep, Ipp16u* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp16u* pBuffer);

IppStatusippiFilterMinBorder_16s_C4R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp16s* pBuffer);

IppStatusippiFilterMinBorder_32f_C4R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp32f* pBuffer);
IppStatus ippiFilterMinBorder_16s_C3R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, const Ipp16s pBorderValue[3], Ipp8u* pBuffer);

IppStatus ippiFilterMinBorder_16u_C3R(const Ipp16u* pSrc, int srcStep, Ipp16u* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, const Ipp16u pBorderValue[3], Ipp8u* pBuffer);

IppStatus ippiFilterMinBorder_32f_C3R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, const Ipp32f pBorderValue[3], Ipp8u* pBuffer);

IppStatus ippiFilterMinBorder_8u_AC4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, const Ipp8u pBorderValue[3], Ipp8u* pBuffer);

IppStatus ippiFilterMinBorder_16s_AC4R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, const Ipp16s pBorderValue[4], Ipp8u* pBuffer);

IppStatus ippiFilterMinBorder_16u_AC4R(const Ipp16u* pSrc, int srcStep, Ipp16u* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, const Ipp16u pBorderValue[4], Ipp8u* pBuffer);

IppStatus ippiFilterMinBorder_32f_AC4R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, const Ipp32f pBorderValue[4], Ipp8u* pBuffer);

IppStatus ippiFilterMinBorder_8u_C4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, const Ipp8u pBorderValue[4], Ipp8u* pBuffer);

IppStatus ippiFilterMinBorder_16s_C4R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, const Ipp16s pBorderValue[4], Ipp8u* pBuffer);

IppStatus ippiFilterMinBorder_16u_C4R(const Ipp16u* pSrc, int srcStep, Ipp16u* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, const Ipp16u pBorderValue[4], Ipp8u* pBuffer);

IppStatus ippiFilterMinBorder_32f_C4R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppSize dstRoiSize, IppSize maskSize, IppiBorderType borderType, const Ipp32f pBorderValue[4], Ipp8u* pBuffer);

**Include Files**

ippi.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

pSrc  
Pointer to the source image ROI.

csrcStep  
Distance, in bytes, between the starting points of consecutive lines in the source image.

pDst  
Pointer to the destination image ROI.
**dstStep**

Distance, in bytes, between the starting points of consecutive lines in the destination image.

**dstRoiSize**

Size of the source and destination ROI, in pixels.

**maskSize**

Size of the filter kernel.

**borderType**

Type of border. Possible values are:

- ippBorderConst: Values of all border pixels are set to a constant.
- ippBorderRepl: Border is replicated from the edge pixels.
- ippBorderInMem: Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, or ippBorderMirror values and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.

**borderValue**

Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

**pBorderValue[3], pBorderValue[4]**

Pointer to constant values to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

**pBuffer**

Pointer to the work buffer.

**Description**

Before using the ippiFilterMaxBorder and ippiFilterMinBorder functions, you need to compute the size of the work buffer pBuffer using the ippiFilterMaxBorderGetBufferSize or ippiFilterMinBorderGetBufferSize functions, respectively.

These functions operate with ROI (see Regions of Interest in Intel IPP).

The ippiFilterMaxBorder and ippiFilterMinBorder functions apply the maximum/minimum filters, respectively, to the source image ROI. The size of the source image ROI is equal to the destination image ROI size dstRoiSize. The values of border pixels are assigned in accordance with the borderType and borderValue parameters. The kernel size of the filter is arbitrary and depends on the mask value.

The anchor cell is the center cell of the kernel, highlighted in red. The anchor cell is defined as:

\[
x = \frac{(maskSize.width - 1)/2}{y = \frac{(maskSize.height - 1)/2}
\]

where

\((x, y)\) are cell coordinates.

**Return Values**

- ippStsNoErr: Indicates no error.
Indicates an error when one of the specified pointers is NULL.
Indicates an error when \( \text{dstRoiSize} \) is negative, or equal to zero.
Indicates an error when \( \text{mask} \) is less than, or equal to zero.
Indicates an error when \( \text{borderType} \) has an illegal value.

**See Also**
Borders in Neighborhood Operations
Regions of Interest in Intel IPP
User-defined Border Types
FilterMaxBorderGetBufferSize, FilterMinBorderGetBufferSize  Compute the size of the work buffer for the maximum/minimum filter.

DecimateFilterRow, DecimateFilterColumn
*Decimates an image by rows or by columns.*

**Syntax**

\[
\text{IppStatus ippiDecimateFilterRow\_8u\_C1R(const Ipp8u* pSrc, int srcStep, IppiSize srcRoiSize, Ipp8u* pDst, int dstStep, IppiFraction fraction);} \\
\text{IppStatus ippiDecimateFilterColumn\_8u\_C1R(const Ipp8u* pSrc, int srcStep, IppiSize srcRoiSize, Ipp8u* pDst, int dstStep, IppiFraction fraction);} \\
\]

**Include Files**

ippi.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- \( pSrc \)  
  Pointer to the source image ROI.
- \( \text{srcStep} \)  
  Distance in bytes between starts of consecutive lines in the source image.
- \( \text{srcRoiSize} \)  
  Size of the source image ROI in pixels.
- \( pDst \)  
  Pointer to the destination image.
- \( \text{dstStep} \)  
  Distance in bytes between starts of consecutive lines in the destination image.
- \( \text{fraction} \)  
  Specifies how the decimating is performed. Possible values:
  - ippPolyphase\_1\_2,
  - ippPolyphase\_3\_5,
  - ippPolyphase\_2\_3,
  - ippPolyphase\_7\_10,
  - ippPolyphase\_3\_4.
Description
These functions operate with ROI (see Regions of Interest in Intel IPP).

Functions `DecimateFilterRow` and `DecimateFilterColumn` perform decimating of the source image by rows or by columns respectively. These functions use the set of special internal polyphase filters. The parameter `fraction` specifies how the decimating is performed, for example, if the parameter is set to `ippPolyphase_3_5`, then each 5 pixels in the row (or column) of the source image give 3 pixels to the destination image, if the parameter is set to `ippPolyphase_1_2`, then each two pixels in the row (or column) of the source image give 1 pixel to the destination image, and so on.

To ensure valid operation, the application must correctly define additional border pixels (see Borders in Neighborhood Operations). For all `fraction` values the width of the border is four columns/rows all around the source image ROI.

Return Values
- `ippStsNoErr` Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr` Indicates an error if one of the specified pointers is `NULL`.
- `ippStsSizeErr` Indicates an error if `roiSize` has a field with a zero or negative value.
- `ippStsStepErr` Indicates an error if `srcStep` or `dstStep` is less than or equal to zero.
- `ippStsDecimateFractionErr` Indicates an error if `fraction` has an illegal value.

Median Filters
The median filter functions perform non-linear filtering of a source image data.

These functions use either an arbitrary rectangular mask, or the following predefined masks of the `IppiMaskSize` type to filter an image:

- `ippMskSize3x1` Horizontal mask of length 3
- `ippMskSize5x1` Horizontal mask of length 5
- `ippMskSize1x3` Vertical mask of length 3
- `ippMskSize3x3` Square mask of size 3
- `ippMskSize1x5` Vertical mask of length 5
- `ippMskSize5x5` Square mask of size 5

The size of the neighborhood and coordinates of the anchor cell in the neighborhood depend on the `mask` mean value. Table “Median Filter Mask, Neighborhood, and Anchor Cell” lists the mask types with the corresponding neighborhood sizes and anchor cell coordinates. Mask size in mask names is indicated in `(XY)` order. The anchor cell is specified by its coordinates `anchor.x` and `anchor.y` in the coordinate system associated with the upper left corner of the mask.

Median Filter Mask, Neighborhood, and Anchor Cell

<table>
<thead>
<tr>
<th>Mask</th>
<th>Neighborhood Size</th>
<th>Anchor Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>ippMskSize3x1</code></td>
<td>Columns 3, Rows 1</td>
<td>[1, 0]</td>
</tr>
</tbody>
</table>
Median filters have the effect of removing the isolated intensity spikes and can be used to reduce noise in an image.

For details on algorithms used in Intel IPP for median filtering, see [APMF].

### FilterMedianBorderGetBufferSize

**Computes the size of the work buffer for the FilterMedianBorder function.**

#### Syntax

```c
IppStatus ippiFilterMedianBorderGetBufferSize (IppiSize dstRoiSize, IppiSize maskSize, IppDataType dataType, int numChannels, int* pBufferSize);
```

#### Include Files

ippi.h

#### Parameters

- **dstRoiSize**: Size of the destination ROI, in pixels.
- **maskSize**: Size of the filter mask, in pixels.
- **dataType**: Data type of the source and destination images. Possible values are ipp8u, ipp16u, ipp16s, or ipp32f.
- **numChannels**: Number of channels in the image. Possible values are 1, 3, or 4.
- **pBufferSize**: Pointer to the computed size of the external work buffer, in bytes.

#### Description

The `ippiFilterMedianBorderGetBufferSize` function computes the size, in bytes, of the external work buffer needed for the `ippiFilterMedianBorder` function. The result is stored in the `pBufferSize` parameter.

For an example on how to use this function, see the code example provided with the `ippiFilterMedianBorder` function description.

#### Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error when `pBufferSize` is NULL.
Indicates an error when one of the dstRoiSize fields has a negative or zero value.

ippStsMaskSizeErr
Indicates an error when mask has a field with a negative, zero, or even value.

ippStsDataTypeErr
Indicates an error when dataType has an illegal value.

ippStsNumChannelsError
Indicates an error when numChannels has an illegal value.

**See Also**
FilterMedianBorder  Performs median filtering of an image.

**FilterMedianBorder**
*Performs median filtering of an image.*

**Syntax**

**Case 1: Operating on one-channel data**

IppStatus ippiFilterMedianBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, Ipp<datatype> borderValue, Ipp8u* pBuffer);

Supported values for mod:

8u_C1R  16u_C1R  16s_C1R  32f_C1R

**Case 2: Operating on multi-channel data**

IppStatus ippiFilterMedianBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp<datatype> pBorderValue[3], Ipp8u* pBuffer);

Supported values for mod:

8u_C3R  16u_C3R  16s_C3R
8u_AC4R  16u_AC4R  16s_AC4R

IppStatus ippiFilterMedianBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiBorderType borderType, const Ipp<datatype> pBorderValue[4], Ipp8u* pBuffer);

Supported values for mod:

8u_C4R  16u_C4R  16s_C4R

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

pSrc  Pointer to the source image.
srcStep
Distance, in bytes, between the starting points of consecutive lines in the source image.

pDst
Pointer to the destination image.

dstStep
Distance, in bytes, between the starting points of consecutive lines in the destination image.

dstRoiSize
Size of the destination ROI, in pixels.

maskSize
Size of the filter mask, in pixels.

borderType
Type of border. Possible values are:

ippBorderConst Values of all border pixels are set to constant.

ippBorderRepl Border is replicated from the edge pixels.

ippBorderInMem Border is obtained from the source image pixels in memory.

borderValue
Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

pBorderValue[3], pBorderValue[4]
Pointer to the constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

pBuffer
Pointer to the work buffer.

Description
This function operates with ROI.

Before using this function, you need to compute the size of the work buffer pBuffer using theippiFilterMedianBorderGetBufferSize function.

The ippiFilterMedianBorder function applies a median filter to an image ROI. The anchor cell is the center of the filter kernel. The size of the source image ROI is equal to the size of the destination image ROI dstRoiSize.

This function sets each pixel in the destination buffer as the median value of all source pixels values from the neighborhood of the processed pixel.

This function removes noise and does not cut out signal brightness drops, as an averaging filter does.

Return Values

ippiStsNoErr Indicates no error.

ippiStsNullPtrErr Indicates an error when pSrc, pDst, pBuffer is NULL.

ippiStsSizeErr Indicates an error if dstRoiSize has a field with a zero or negative value.

ippiStsMaskSizeErr Indicates an error if maskSize has a field with a zero, negative, or even value.

ippiStsNotEvenStepErr Indicates an error if one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.
indicates an error when \texttt{borderType} has an illegal value.

Example

To better understand usage of this function, refer to the Filter\texttt{MedianBorder.c} example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

See Also

Regions of Interest in Intel IPP
User-defined Border Types
Filter\texttt{MedianBorderGetBufferSize} Computes the size of the work buffer for the Filter\texttt{MedianBorder} function.

Filter\texttt{MedianGetBufferSize}

\textit{Computes the size of the external buffer for \texttt{ippiFilterMedian} function.}

Syntax

\begin{verbatim}
IppStatus ippiFilterMedianGetBufferSize_32f(IppiSize dstRoiSize, IppiSize maskSize, Ipp32u nChannels, Ipp32u* pBufferSize);
IppStatus ippiFilterMedianGetBufferSize_64f(IppiSize dstRoiSize, IppiSize maskSize, Ipp32u nChannels, Ipp32u* pBufferSize);
\end{verbatim}

Include Files

\texttt{ippi.h}

Domain Dependencies

Headers: \texttt{ippcore.h, ippvm.h, ipps.h}
Libraries: \texttt{ippcore.lib, ippvm.lib, ipps.lib}

Parameters

\begin{description}
\item \texttt{dstRoiSize} \hspace{1cm} Size of the destination ROI in pixels.
\item \texttt{maskSize} \hspace{1cm} Size of the mask in pixels.
\item \texttt{nChannels} \hspace{1cm} Number of channels in the image.
\item \texttt{pBufferSize} \hspace{1cm} Pointer to the computed value of the external buffer size.
\end{description}

Description

This function computes the size in bytes of an external memory buffer that is required for the \texttt{ippiFilterMedian} function, and stores the result in the \texttt{pBufferSize}.

Return Values

\begin{description}
\item \texttt{ippStsNoErr} \hspace{1cm} Indicates no error. Any other value indicates an error.
\item \texttt{ippStsNullPtrErr} \hspace{1cm} Indicates an error if the \texttt{pBufferSize} pointer is NULL.
\item \texttt{ippStsSizeErr} \hspace{1cm} Indicates an error if one of the fields of \texttt{dstRoiSize} has a zero or negative value.
\end{description}
FilterMedian

*Filters an image using a median filter.*

**Syntax**

```c
IppStatus ippiFilterMedian_<mod>(const Ipp<datatype> * pSrc, int srcStep, Ipp<datatype> * pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiPoint anchor, Ipp8u* pBuffer);
```

**Supported values for mod:**

- `32f_C3R`
- `32f_C4R`
- `64f_C1R`

**Include Files**

`ippi.h`

**Domain Dependencies**

**Headers:** `ippcore.h`, `ippvm.h`, `ipps.h`

**Libraries:** `ippcore.lib`, `ippvm.lib`, `ipps.lib`

**Parameters**

- `pSrc` : Pointer to the source image ROI.
- `srcStep` : Distance in bytes between starts of consecutive lines in the source image.
- `pDst` : Pointer to the destination image ROI.
- `dstStep` : Distance in bytes between starts of consecutive lines in the destination image.
- `dstRoiSize` : Size of the source and destination ROI in pixels.
- `maskSize` : Size of the mask in pixels.
- `anchor` : Anchor cell specifying the mask alignment with respect to the position of the input pixel.
- `pBuffer` : Pointer to the external work buffer.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function sets each pixel in the output buffer as the median value of all the input pixel values taken in the neighborhood of the processed pixel. To ensure valid operation when image boundary pixels are processed, the application should correctly define additional border pixels (see Borders in Neighborhood Operations).
The anchor cell is specified by its coordinates anchor.x and anchor.y in the coordinate system associated with the top left corner of the kernel. The size of the source image ROI is equal to the size of the destination image ROI dstRoiSize.

Some flavors of the function require the external buffer pBuffer. Prior to using this functions, compute the size of the external buffer by using the function FilterMedianGetBufferSize.

Return Values

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error if pSrc or pDst is NULL.
- ippStsSizeErr: Indicates an error if dstRoiSize has a field with a zero or negative value.
- ippStsStepErr: Indicates an error if srcStep or dstStep has a zero or negative value.
- ippStsMaskSizeErr: Indicates an error if maskSize has a field with zero, negative, or even value.
- ippStsAnchorErr: Indicates an error if anchor is outside the mask size.

FilterMedianCross

Filters an image using a cross median filter.

Syntax

IppStatus ippiFilterMedianCross_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask);

Supported values for mod:

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 8u_C3R
- 16u_C3R
- 16s_C3R
- 8u_AC4R
- 16u_AC4R
- 16s_AC4R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- pSrc: Pointer to the source image ROI.
- srcStep: Distance in bytes between starts of consecutive lines in the source image.
- pDst: Pointer to the destination image ROI.
- dstStep: Distance in bytes between starts of consecutive lines in the destination image.


dstRoiSize

Size of the source and destination ROI in pixels.

mask

Predefined mask of the IppiMaskSize type.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function sets each pixel in the output buffer as the median value of all the input pixel values taken in the neighborhood of the processed pixel. The neighborhood is determined by the square mask of the predefined size, which can be either ippMskSize3x3 or ippMskSize5x5 (see Table “Median Filter Mask, Neighborhood, and Anchor Cell”). The function operates on the assumption that the pixels outside the source image ROI exist along the distance equal to half of the mask size. It means that the application program should provide appropriate values for the pSrc and dstRoiSize arguments, or define additional border pixels (see Borders in Neighborhood Operations). The size of the source image ROI is equal to the size of the destination image ROI dstRoiSize.

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr

Indicates an error if pSrc or pDst is NULL.

ippStsSizeErr

Indicates an error if dstRoiSize has a field with a zero or negative value.

ippStsStepErr

Indicates an error if srcStep or dstStep has a zero or negative value.

ippStsMaskSizeErr

Indicates an error if mask has an illegal value.

FilterMedianWeightedCenter3x3

Filters an image using a median filter with a weighted center pixel.

Syntax

IppStatus ippiFilterMedianWeightedCenter3x3_8u_C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize dstRoiSize, int weight);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc

Pointer to the source image ROI.

srcStep

Distance in bytes between starts of consecutive lines in the source image.

pDst

Pointer to the destination image ROI.
**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function sets each pixel in the destination image as the median value of all the input pixel values taken in the neighborhood of the processed pixel. The neighborhood is determined by the fixed square mask of the 3x3 size with the anchor cell as the center cell of the mask. The parameter \textit{weight} specifies the weight of the processed pixel, that is how many times its value is included into calculations. The value of this parameter should be odd. If it is even, the function changes its value to the nearest less odd number and returns the warning message.

The function operates on the assumption that the pixels outside of the source image ROI exist along the distance equal to half of the mask size. It means that the application program should provide appropriate values for the \textit{pSrc} and \textit{dstRoiSize} arguments, or define additional border pixels (see Borders in Neighborhood Operations). The size of the source image ROI is equal to the size of the destination image ROI \textit{dstRoiSize}.

**Return Values**

- \textbf{ippStsNoErr} Indicates no error. Any other value indicates an error or a warning.
- \textbf{ippStsNullPtrErr} Indicates an error if \textit{pSrc} or \textit{pDst} is NULL.
- \textbf{ippStsSizeErr} Indicates an error if \textit{dstRoiSize} has a field with a zero or negative value.
- \textbf{ippStsStepErr} Indicates an error if \textit{srcStep} or \textit{dstStep} has a zero or negative value.
- \textbf{ippStsWeightErr} Indicates an error if \textit{weight} is less than or equal to 0.
- \textbf{ippStsEvenMedianWeight} Indicates a warning if \textit{weight} has an even value.

**FilterMedianColor**

\textit{Filters an image using a color median filter.}

**Syntax**

\texttt{IppStatus ippiFilterMedianColor}_\langle \texttt{mod} \rangle (const Ipp<datatype>* \textit{pSrc}, int \textit{srcStep}, Ipp<datatype>* \textit{pDst}, int \textit{dstStep}, IppiSize \textit{dstRoiSize}, IppiMaskSize \textit{mask});

**Supported values for \texttt{mod}:**

- \texttt{8u\textunderscore C3R}
- \texttt{16s\textunderscore C3R}
- \texttt{32f\textunderscore C3R}
- \texttt{8u\textunderscore AC4R}
- \texttt{16s\textunderscore AC4R}
- \texttt{32f\textunderscore AC4R}

**Include Files**

\texttt{ippi.h}

**Domain Dependencies**

Headers: \texttt{ippcore.h, ippvm.h, ipps.h}
Libraries: ippcore.lib, ippvm.lib, ippss.lib

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **dstRoiSize**: Size of the source and destination ROI in pixels.
- **mask**: Predefined mask of the IppiMaskSize type.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

When applied to a color image, the previously described median filtering functions process color planes of an image separately, and as a result any correlation between color components is lost. If you want to preserve this information, use theippiFilterMedianColor function instead. For each input pixel, this function computes differences between red (R), green (G), and blue (B) color components of pixels in the mask neighborhood and the input pixel. The distance between the input pixel \( i \) and the neighborhood pixel \( j \) is formed as the sum of absolute values:

\[
\text{abs} (R(i)-R(j)) + \text{abs} (G(i)-G(j)) + \text{abs} (B(i)-B(j))
\]

After scanning the entire neighborhood, the function sets the output value for pixel \( i \) as the value of the neighborhood pixel with the smallest distance to \( i \).

The function ippiFilterMedianColor supports square masks of size either ippMskSize3x3 or ippMskSize5x5 and processes color images only. To ensure valid operation when image boundary pixels are processed, the application should correctly define additional border pixels (see Borders in Neighborhood Operations).

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error if **pSrc** or **pDst** is NULL.
- **ippStsSizeErr**: Indicates an error if **dstRoiSize** has a field with a zero or negative value.
- **ippStsStepErr**: Indicates an error if **srcStep** or **dstStep** has a zero or negative value.
- **ippStsMaskSizeErr**: Indicates an error if **mask** has an illegal value.

General Linear Filters

These functions use a general rectangular kernel to filter an image. The kernel is a matrix of signed integers or single-precision real values. For each input pixel, the kernel is placed on the image in such a way that the fixed anchor cell within the kernel coincides with the input pixel. The anchor cell is usually a geometric center of the kernel, but can be skewed with respect to the geometric center.
A pointer to an array of kernel values is passed to filtering functions. These values are read in row-major order starting from the top left corner. This array must exactly have \( \text{kernelSize.width} \times \text{kernelSize.height} \) entries. The anchor cell is specified by its coordinates \( \text{anchor.x} \) and \( \text{anchor.y} \) in the coordinate system associated with the lower right corner of the kernel.

The output value is computed as a sum of neighbor pixels values, with kernel matrix elements used as weight factors. Summation formulas implement a convolution operation, which means that kernel coefficients are used in direct order.

**NOTE**
In Intel IPP 8.2 and lower versions, kernel coefficients are used in inverse order.

Optionally, the output pixel values may be scaled. To ensure valid operation when image boundary pixels are processed, the application should correctly define additional border pixels (see Borders in Neighborhood Operations).

**FilterBorderGetSize**
*Computes the size of the filter specification structure and the size of the work buffer.*

**Syntax**

```
IppStatus ippiFilterBorderGetSize (IppiSize kernelSize, IppiSize dstRoiSize, IppDataType dataType, IppDataType kernelType, int numChannels, int* pSpecSize, int* pBufferSize);
```

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- `kernelSize`: Size of the rectangular kernel in pixels.
- `dstRoiSize`: Maximal size of the destination image ROI (in pixels).
- `dataType`: Data type of the source image. Possible values are ipp8u, ipp16u, ipp16s, ipp32f, or ipp64f.
- `kernelType`: Data type of the filter kernel. Possible values are ipp16s, ipp32f, or ipp64f.
- `numChannels`: Number of channels in the image. Possible values are 1, 3, or 4.
- `pSpecSize`: Pointer to the size of the filter specification structure.
- `pBufferSize`: Pointer to the size of the work buffer required for filtering.

**Description**

This function operates with ROI.

This function computes the size of the filter specification structure `pSpec` and the size of the buffer required for filtering operations. Call this function before using the `ippiFilterBorderInit` function.
Return Values

- **ippStsNoErr**
  Indicates no error.
- **ippStsNullPtrErr**
  Indicates an error when one of the specified pointers is NULL.
- **ippStsSizeErr**
  Indicates an error when `kernelSize` has a field with a zero or negative value, or if `dstRoiSize` is less than 1.
- **ippStsDataTypeErr**
  Indicates an error when `dataType` or `kernelType` has an illegal value.
- **ippStsChannelErr**
  Indicates an error when `numChannels` has an illegal value.

See Also

- Regions of Interest in Intel IPP
- FilterBorderInit  Initializes the filter specification structure.
- FilterBorder  Filters an image using a rectangular filter.

FilterBorderInit

**Initializes the filter specification structure.**

Syntax

```c
IppStatus ippiFilterBorderInit_16s(const Ipp16s* pKernel, IppiSize kernelSize, int divisor, IppDataType dataType, int numChannels, IppRoundMode roundMode, IppFilterBorderSpec* pSpec);
IppStatus ippiFilterBorderInit_32f(const Ipp32f* pKernel, IppiSize kernelSize, IppDataType dataType, int numChannels, IppRoundMode roundMode, IppFilterBorderSpec* pSpec);
IppStatus ippiFilterBorderInit_64f(const Ipp64f* pKernel, IppiSize kernelSize, IppDataType dataType, int numChannels, IppRoundMode roundMode, IppFilterBorderSpec* pSpec);
```

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pKernel**
  Pointer to the kernel values.
- **kernelSize**
  Size of the rectangular kernel in pixels.
- **divisor**
  Integer value by which the computed result is divided.
- **dataType**
  Data type of the source image. Possible values are ipp8u, ipp16u, ipp16s, ipp32f, or ipp64f.
- **numChannels**
  Number of channels in the image. Possible values are 1, 3, or 4.
roundMode

Rounding mode, possible values:

ippRndZero  
Floating-point values are truncated to zero.

ippRndNear  
Floating-point values are rounded to the nearest even integer when the fractional part equals to 0.5; otherwise they are rounded to the nearest integer.

ippRndFinancial  
Floating-point values are rounded down to the nearest integer when the fractional part is less than 0.5, or rounded up to the nearest integer if the fractional part is equal or greater than 0.5.

ippRndHintAccurate  
The result of calculations is accurate. This mode is supported only when:
- \( \text{dataType} \) is equal to 8u and \( \text{numChannels} \) is equal to 1, 3, or 4
- \( \text{dataType} \) is equal to 16s and \( \text{numChannels} \) is equal to 1

pSpec

Pointer to the filter specification structure.

Description

This function initializes the filter specification structure \( pSpec \) in the external buffer. Before using this function, you need to compute the size of the specification structure using the FilterBorderGetSize function. This structure is used by the FilterBorder function that performs filtering operations on the source image pixels.

Return Values

ippiStsNoErr  
Indicates no error.

ippiStsNullPtrErr  
Indicates an error when one of the specified pointers is NULL.

ippiStsSizeErr  
Indicates an error when \( \text{kernelSize} \) has a field with a zero or negative value.

ippiStsDataTypeErr  
Indicates an error when \( \text{dataType} \) has an illegal value.

ippiStsRoundModeNotSupportedErr  
Indicates an error when the specified rounding mode is not supported.

ippiStsAccurateModeNotSupported  
Indicates a warning when the ippRndHintAccurate mode is not supported.

See Also

FilterBorderGetSize  
Computes the size of the filter specification structure and the size of the work buffer.

FilterBorder  
Filters an image using a rectangular filter.

FilterBorder

Filters an image using a rectangular filter.
Syntax

Case 1: Operation on one-channel data

IppStatus ippiFilterBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppSize dstRoiSize, IppiBorderType border, const Ipp<datatype> borderValue[1], const IppiFilterBorderSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R
- 64f_C1R

Case 2: Operation on multi-channel data

IppStatus ippiFilterBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppSize dstRoiSize, IppiBorderType border, const Ipp<datatype> borderValue[3], const IppiFilterBorderSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R

Case 2: Operation on multi-channel data

IppStatus ippiFilterBorder_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppSize dstRoiSize, IppiBorderType border, const Ipp<datatype> borderValue[4], const IppiFilterBorderSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

- 8u_C4R
- 16u_C4R
- 16s_C4R
- 32f_C4R

Include Files
ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance, in bytes, between the starting points of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
**dstStep**
Distance, in bytes, between starting points of consecutive lines in the destination image.

**dstRoiSize**
Size of the source and destination image ROI in pixels.

**border**
Type of border. Possible values are:
- ippBorderConst: Values of all border pixels are set to constant.
- ippBorderRepl: Border is replicated from the edge pixels.
- ippBorderInMem: Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between the ippBorderRepl or ippBorderConst values and ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight.

**borderValue**
Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

**pSpec**
Pointer to the filter specification structure.

**pBuffer**
Pointer to the work buffer for filtering operations.

**Description**
Before using this function, you need to initialize the filter specification structure using the ippiFilterBorderInit function.

This function operates with ROI.

This function performs filtering of a rectangular ROI inside a two-dimensional image using a specified structure pSpec. Type of the image border is defined by the value of the border parameter.

To change the function behavior (add offset to the result or set the rounding mode), use ippiFilterBorderSetMode after the ippiFilterBorderInit function.

**Return Values**
- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error when one of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error when dstRoiSize has a field with a zero or negative value, or if dstRoiSize.width is more than the maximum ROI roiWidth passed to the initialization function.
- ippStsStepErr: Indicates an error when the srcStep value is less than, or equal to zero.
- ippStsBorderErr: Indicates an error when border has an illegal value.
Example
To better understand usage of this function, refer to the FilterBorder.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

See Also
Regions of Interest in Intel IPP
User-defined Border Types
FilterBorderInit  Initializes the filter specification structure.
FilterBorderSetMode  Adds the offset value after filtering operation for ipp8u and ipp16u data types, and sets the rounding mode.

FilterBorderSetMode
Adds the offset value after filtering operation for ipp8u and ipp16u data types, and sets the rounding mode.

Syntax
IppStatus ippiFilterBorderSetMode(IppHintAlgorithm hint, int offset, IppiFilterBorderSpec* pSpec);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

hint  Suggests using specific code for rounding. Supported values:

ippiAlgHintNone, ippAlgHintFast  Default modes. The function performs rounding in accordance with the roundMode parameter passed to the Init function, but function performance takes precedence over accuracy and some output pixels can differ by ±1 from the exact result.

ippiAlgHintAccurate  All output pixels are exact; accuracy takes precedence over performance.

offset  Constant that is added to the final signed result before converting it to unsigned for ipp8u and ipp16u data types.

pSpec  Pointer to the initialized filter specification structure.

Description
This function adds the offset value after filtering operation for ipp8u and ipp16u data types with the ippiFilterBorder function:

\[ p\text{Dst} = (\text{sum}(src[i] \times \text{kern}[i])) + \text{offset} \]

You can also use this function to set the rounding mode for the filtering result.
The 8u_C1R, 8u_C3R, 8u_C4R, and 16s_C1RFilterBorder function flavors initialized with the ipp16s coefficients support ippAlgHintNone and ippAlgHintAccurate rounding modes.

Use this function after the ippiFilterBorderInit function and before calling ippiFilterBorder.

**Return Values**

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error when one of the specified pointers is NULL.
- ippStsNotSupportedModeErr: The offset value is not supported (for ipp16s and ipp32f data types).
- ippStsAccurateModeNotSupported: The accurate mode is not supported for some data types. The result of rounding may be not exact.

**Example**

To better understand usage of this function, refer to the FilterBorderSetMode.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

**See Also**

FilterBorder Filters an image using a rectangular filter.
FilterBorderInit Initializes the filter specification structure.

---

**FilterGetBufSize**

*Computes the size of the work buffer.*

**Syntax**

IppStatus ippiFilterGetBufSize_64f_C1R(IppSize kernelSize, int roiWidth, int* pSize);

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- kernelSize: Size of the rectangular kernel in pixels.
- roiWidth: Width of the image ROI in pixels.
- pSize: Pointer to the size of the work buffer.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function computes the size of the work buffer pSize that is required for the function ippiFilter (flavor that operates on data of the Ipp64f type).

**Return Values**

- ippStsNoErr: Indicates no error. Any other value indicates an error.
indicating an error if pSize is NULL.

ippStsSizeErr

Indicates an error if kernelSize has a field with a zero or negative value, or roiWidth is less than or equal to zero.

Filter
Filters an image using a general rectangular kernel.

Syntax

IppStatus ippiFilter_64f_C1R(const Ipp64f* pSrc, int srcStep, Ipp64f* pDst, int dstStep, IppSize dstRoiSize, const Ipp64f* pKernel, IppSize kernelSize, IppiPoint anchor, Ipp8u* pBuffer);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc
Pointer to the source image ROI.

srcStep
Distance, in bytes, between the starting points of consecutive lines in the source image.

pDst
Pointer to the destination image ROI.

dstStep
Distance, in bytes, between the starting points of consecutive lines in the destination image.

dstRoiSize
Size of the source and destination ROI in pixels.

pKernel
Pointer to the kernel values.

kernelSize
Size of the rectangular kernel in pixels.

anchor
Anchor cell specifying the rectangular kernel alignment with respect to the position of the input pixel.

 pBuffer
Pointer to the work buffer.

Description

This function operates with ROI.

The ippiFilter function uses the general rectangular kernel of kernelSize size to filter an image ROI. This function sums the products of the kernel coefficients pKernel and pixel values taken over the source pixel neighborhood defined by kernelSize and anchor. The anchor cell is specified by its coordinates anchor.x and anchor.y in the coordinate system associated with the bottom right corner of the kernel.

Kernel coefficients are used in inverse order. The sum is written to the destination pixel.

To ensure valid operation when image boundary pixels are processed, the application should correctly define additional border pixels (see Borders in Neighborhood Operations).

This function requires a temporary work buffer. Before using this function flavor, you need to compute the buffer size using the ippiFilterGetBufSize function.
Return Values

- ippStsNoErr: Indicates no error. Any other value indicates an error.
- ippStsNullPtrErr: Indicates an error when pSrc, pDst, or pKernel is NULL.
- ippStsSizeErr: Indicates an error when dstRoiSize or kernelSize has a field with a zero or negative value.
- ippStsDivisorErr: Indicates an error when the divisor has a zero value.
- ippStsStepErr: Indicates an error when:
  - srcStep is less than (roiSize.width + kernelSize.width)*sizeof(Ipp64f)
  - dstStep is less than roiSize.width*sizeof(Ipp64f)

See Also

Regions of Interest in Intel IPP
Borders in Neighborhood Operations
FilterGetBufSize Computes the size of the work buffer.

Separable Filters

Separable filters use a spatial kernel consisting of a single column (as in the FilterColumn function) or a single row (as in the FilterRow function) to filter the source image.

FilterRowBorderPipelineGetBufferSize, FilterRowBorderPipelineGetBufferSize_Low
Compute the size of working buffer for the strow filter.

Syntax

IppStatus ippiFilterRowBorderPipelineGetBufferSize_<mod>(IppiSize roiSize, int kernelSize, int* pBufferSize);

Supported values for mod:

- 8u16s_C1R
- 16s_C1R
- 16u_C1R
- 32f_C1R
- 8u16s_C3R
- 16s_C3R
- 16u_C3R
- 32f_C3R

IppStatus ippiFilterRowBorderPipelineGetBufferSize_Low_<mod>(IppiSize roiSize, int kernelSize, int* pBufferSize);

Supported values for mod:

- 16s_C1R
- 16s_C3R

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
**Parameters**

- **roiSize**: Maximum size of the source and destination image ROI.
- **kernelSize**: Size of the kernel in pixels.
- **pBufferSize**: Pointer to the computed size of the buffer.

**Description**

These functions operate with ROI (see Regions of Interest in Intel IPP).

These functions compute the size of the working buffer required for the functions `ippiFilterRowBorderPipeline` and `ippiFilterRowBorderPipeline_Low` respectively. The buffer with the length `pBufferSize[0]` can be used to filter images with width equal to or less than `roiSize`.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if the pointer `pBufferSize` is NULL.
- **ippStsSizeErr**: Indicates an error condition if `maskSize` has a field with a zero or negative value, or if `roiWidth` is less than 1.

**FilterRowBorderPipeline, FilterRowBorderPipeline_Low**

Apply the filter with border to image rows.

**Syntax**

**Case 1: Operation on one-channel integer data**

```c
IppStatus ippiFilterRowBorderPipeline_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>** ppDst, IppiSize roiSize, const Ipp<dstDatatype>* pKernel, int kernelSize, int xAnchor, IppiBorderType borderType, Ipp<srcDatatype> borderValue, int divisor, Ipp8u* pBuffer);
```

Supported values for `mod`:

- 8u16s_C1R
- 16s_C1R
- 16u_C1R

```c
IppStatus ippiFilterRowBorderPipeline_Low_16s_C1R(const Ipp16s* pSrc, int srcStep, IppiSize roiSize, const Ipp16s* pKernel, int kernelSize, int xAnchor, IppiBorderType borderType, Ipp16s borderValue, int divisor, Ipp8u* pBuffer);
```

**Case 2: Operation on one-channel floating point data**

```c
IppStatus ippiFilterRowBorderPipeline_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f** ppDst, IppiSize roiSize, const Ipp32f* pKernel, int kernelSize, int xAnchor, IppiBorderType borderType, Ipp32f borderValue, Ipp8u* pBuffer);
```

*Filtering Functions*
Case 3: Operation on three-channel integer data

IppStatusippiFilterRowBorderPipeline_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>** ppDst, IppiSize roiSize, const Ipp<dstDatatype>* pKernel, int kernelSize, int xAnchor, IppiBorderType borderType, Ipp<srcDatatype> borderValue[3], int divisor, Ipp8u* pBuffer);

Supported values for mod:

8u16s_C3R 16s_C3R 16u_C3R

IppStatusippiFilterRowBorderPipeline_Low_16s_C3R(const Ipp16s* pSrc, int srcStep, Ipp16s** ppDst, IppiSize roiSize, const Ipp16s* pKernel, int kernelSize, int xAnchor, IppiBorderType borderType, Ipp16s borderValue[3], int divisor, Ipp8u* pBuffer);

Case 4: Operation on three-channel floating point data

IppStatusippiFilterRowBorderPipeline_32f_C3R(const Ipp32f* pSrc, int srcStep, Ipp32f** ppDst, IppiSize roiSize, const Ipp32f* pKernel, int kernelSize, int xAnchor, IppiBorderType borderType, Ipp32f borderValue[3], Ipp8u* pBuffer);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc
Pointer to the source image ROI.

srcStep
Distance in bytes between starts of consecutive lines in the source image.

ppDst
Double pointer to the destination image ROI.

roiSize
Size of the source and destination ROI in pixels.

pKernel
Pointer to the row kernel values.

kernelSize
Size of the kernel in pixels.

xAnchor
Anchor value specifying the kernel row alignment with respect to the position of the input pixel.

borderType
Type of border (see Borders in Neighborhood Operations); following values are possible:

ippBorderZero
Values of all border pixel are set to zero.

ippBorderConst
Values of all border pixels are set to constant.

ippBorderRepl
Replicated border is used.

ippBorderWrap
Wrapped border is used

ippBorderMirror
Mirrored border is used
Mirrored border with replication is used

**borderValue**

The constant value (constant vector in case of three-channel data) to assign to the pixels in the constant border (not applicable for other border’s type).

**divisor**

Value by which the computed result is divided (for operations on integer data only).

**pBuffer**

Pointer to the working buffer.

**Description**

These functions operate with ROI (see Regions Regions of Interest in Intel IPP).

The function `ippiFilterRowBorderPipeline_Low` performs calculation exclusively with the 16s-data, and the input data must be in the range ensuring that the overflow does not occur during calculation and the result can be represented by a 32-bit integer number.

These functions apply the horizontal row filter of the separable convolution kernel to the source image `pSrc`. The filter coefficients are placed in the reversed order. For integer data:

\[
ppDst[i][j] = \frac{1}{\text{divisor}} \sum_{k=0}^{\text{kernelSize}-1} pSrc[i, j+k-xAnchor] \cdot pKernel[k]
\]

and for floating point data:

\[
ppDst[i][j] = \sum_{k=0}^{\text{kernelSize}-1} pSrc[i, j+k-xAnchor] \cdot pKernel[k]
\]

Here \( j = 0, \ldots \text{roiSize.width}-1, i = 0, \ldots \text{roiSize.height}-1 \). The values of pixels of the source image that lies outside of the image ROI (that is, if for pixel \( pSrc[i,1] \) \( i \not\in [0, \text{roiSize.width}-1] \) are set in accordance with the specified parameters `borderType` and `borderValue`.

This function can be used to organize the separable convolution as a step of the image processing pipeline.

The functions requires the external buffer `pBuffer`, its size should be previously computed by the functions `ippiFilterRowBorderPipelineGetBufferSize` and `ippiFilterRowBorderPipelineGetBufferSize_Low` respectively.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if `roiSize` has a field with a zero or negative value.
- **ippStsStepErr**: Indicates an error condition if `srcStep` or `dstStep` is less than `roiSize.width * <pixelSize>`.
- **ippStsNotEvenStepErr**: Indicates an error condition if one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.
- **ippStsAnchorErr**: Indicates an error condition if `xAnchor` has a wrong value.
FilterColumnPipelineGetBufferSize, FilterColumnPipelineGetBufferSize_Low

Compute the size of working buffer for the column filter.

Syntax

IppStatus ippiFilterColumnPipelineGetBufferSize_<mod>(IppiSize roiSize, int kernelSize, int* pBufferSize);

Supported values for mod:

16s_C1R  16u_C1R  16s8u_C1R  16s8s_C1R  32f_C1R
16s_C3R  16u_C3R  16s8u_C3R  16s8s_C3R  32f_C3R

IppStatus ippiFilterColumnPipelineGetBufferSize_Low_<mod>(IppiSize roiSize, int kernelSize, int* pBufferSize);

Supported values for mod:

16s_C1R
16s_C3R

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

roiSize        Maximum size of the source and destination image ROI.
kernelSize     Size of the kernel in pixels.
pBufferSize    Pointer to the computed size of the buffer.

Description

These functions operate with ROI (see Regions of Interest in Intel IPP).
These functions compute the size of the working buffer required for the functions
ippiFilterColumnPipeline and ippiFilterColumnPipeline_Low respectively. The buffer with the
length pBufferSize[0] can be used to filter images with width equal to or less than roiSize.

Return Values

ippStsNoErr           Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr      Indicates an error condition if the pointer pBufferSize is NULL.
Indicates an error condition if `maskSize` has a field with a zero or negative value, or if `roiWidth` is less than 1.

**FilterColumnPipeline, FilterColumnPipeline_Low**

*Apply the filter to image columns.*

**Syntax**

**Case 1: Operation on integer data**

```c
IppStatus ippiFilterColumnPipeline_<mod>(const Ipp<srcDatatype>** ppSrc, Ipp<dstDatatype>* pDst, int dstStep, IppiSize roiSize, const Ipp<srcDatatype>* pKernel, int kernelSize, int divisor, Ipp8u* pBuffer);
```

Supported values for `mod`:

- `16s_C1R`  `16s8u_C1R`  `16s8s_C1R`  `16u_C1R`
- `16s_C3R`  `16s8u_C3R`  `16s8s_C3R`  `16u_C3R`

```c
IppStatus ippiFilterColumnPipeline_Low_16s_C1R(const Ipp16s** ppSrc, Ipp16s* pDst, int dstStep, IppiSize roiSize, const Ipp16s* pKernel, int kernelSize, int divisor, Ipp8u* pBuffer);
```

```c
IppStatus ippiFilterColumnPipeline_Low_16s_C3R(const Ipp16s** ppSrc, Ipp16s* pDst, int dstStep, IppiSize roiSize, const Ipp16s* pKernel, int kernelSize, int divisor, Ipp8u* pBuffer);
```

**Case 2: Operation on floating-point data**

```c
IppStatus ippiFilterColumnPipeline_<mod>(const Ipp<datatype>** ppSrc, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, const Ipp<datatype>* pKernel, int kernelSize, Ipp8u* pBuffer);
```

Supported values for `mod`:

- `32f_C1R`
- `32f_C3R`

**Include Files**

`ippcv.h`

**Domain Dependencies**

**Headers:** `ippcore.h`, `ippvm.h`, `ipps.h`, `ippi.h`

**Libraries:** `ippcore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`

**Parameters**

- `ppSrc`  Double pointer to the source image ROI.
- `pDst`  Pointer to the destination image ROI.
- `dstStep`  Distance in bytes between starts of consecutive lines in the destination image.
- `roiSize`  Size of the destination ROI in pixels.
- `pKernel`  Pointer to the strow kernel values.
kernelSize  
Size of the kernel in pixels.

divisor  
Value by which the computed result is divided (for operations on integer data only).

pBuffer  
Pointer to the working buffer.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
The function ippiFilterColumnPipeline_Low performs calculation exclusively with the 16s-data, and the input data must be in the range ensuring that the overflow does not occur during calculation and the result can be represented by a 32-bit integer number.

These functions apply the column filter of the separable convolution kernel to the source image pSrc. The filter coefficients are placed in the reversed order. For integer data:

\[ pDst[i,j] = \frac{1}{\text{divisor}} \sum_{k=0}^{\text{kernelSize}-1} pSrc[i+k,j] \cdot pKernel[k] \]

and for floating point data:

\[ pDst[i,j] = \sum_{k=0}^{\text{kernelSize}-1} pSrc[i+k,j] \cdot pKernel[k] \]

Here \( j = 0, \ldots, \text{roiSize.width}-1, i=0, \ldots, \text{roiSize.height}-1. \)

The size of the source image is

\( (\text{roiSize.height} + \text{kernelSize} - 1) \ast \text{roiSize.width}. \)

The functions requires the external buffer pBuffer, its size should be previously computed by the functions ippiFilterColumnPipelineGetBufferSize and ippiFilterColumnPipelineGetBufferSize_Low respectively.

Return Values
ippiStsNoErr  
Indicates no error. Any other value indicates an error.

ippiStsNullPtrErr  
Indicates an error condition if one of the specified pointers is NULL.

ippiStsSizeErr  
Indicates an error condition if roiSize has a field with a zero or negative value.

ippiStsStepErr  
Indicates an error condition if srcStep or dstStep is less than roiSize.width * <pixelSize>.

ippiStsNotEvenStepErr  
Indicates an error condition if one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.

ippiStsBadArgErr  
Indicates an error condition if divisor is equal to 0.

Example
To better understand usage of this function, refer to the FilterColumnPipeline_Low.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.
FilterSeparable
Apply the filter to an image.

Syntax
IppStatus ippiFilterSeparable_<mod>(const Ipp<datatype>* pSrc, int srcStep,
Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType,
Ipp<datatype> borderValue, const IppiFilterSeparableSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u_C1R  16s_C1R  16u_C1R  32f_C1R
8u_C3R  16s_C3R  16u_C3R  32f_C3R
8u_C4R  16s_C4R  16u_C4R  32f_C4R

IppStatus ippiFilterSeparable_<mod>(const Ipp<srcdatatype>* pSrc, int srcStep,
Ipp<dstdatatype>* pDst, int dstStep, IppiSize roiSize, IppiBorderType borderType,
Ipp<srcdatatype> borderValue, const IppiFilterSeparableSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u16s_C1R
8u16s_C3R
8u16s_C4R

Platform-aware functions
IppStatus ippiFilterSeparable_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep,
Ipp<datatype>* pDst, IppSizeL dstStep, IppiSizeL roiSize, IppiBorderType borderType,
Ipp<datatype> borderValue, const IppiFilterSeparableSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u_C1R_L  16s_C1R_L  16u_C1R_L  32f_C1R_L
8u_C3R_L  16s_C3R_L  16u_C3R_L  32f_C3R_L
8u_C4R_L  16s_C4R_L  16u_C4R_L  32f_C4R_L

IppStatus ippiFilterSeparable_<mod>(const Ipp<srcdatatype>* pSrc, IppSizeL srcStep,
Ipp<dstdatatype>* pDst, IppSizeL dstStep, IppiSizeL roiSize, IppiBorderType borderType,
Ipp<srcdatatype> borderValue, const IppiFilterSeparableSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u16s_C1R_L
8u16s_C3R_L
8u16s_C4R_L

Include Files
ippcv.h
ippcv_l.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**: Size of the source and destination ROI in pixels.
- **borderType**: Type of border. Possible values are:
  - ippBorderConst: Values of all border pixels are set to constant.
  - ippBorderRept: Replicated border is used.
  - ippBorderWrap: Wrapped border is used.
  - ippBorderMirror: Mirrored border is used.
  - ippBorderMirrorR: Mirrored border with replication is used.
- **borderValue**: Constant value (constant vector in case of three- or four-channel data) to assign to the pixels in theippiBorderConst border type (not applicable for other border types).
- **pSpec**: Pointer to the filter specification structure.
- **pBuffer**: Pointer to the working buffer.

Description

This function operates with ROI.

Before using this function, compute the size of the external buffer **pBuffer** using theippiFilterSeparableGetSize function.

This function applies the horizontal row filter of the separable convolution kernel to the source image **pSrc** and the column filter of the separable convolution kernel to the intermediate result.

For integer data:

\[
\text{intermediate}[i][j] = \frac{1}{\text{divisor}} \star \sum_{k=0}^{\text{rowKernelSize}-1} (\text{pSrc}[i, j + k - \text{xAnchor}] \star \text{pRowKernel}[k])
\]

\[
pDst[i, j] = \text{offset} + \frac{1}{\text{divisor}} \star \sum_{k=0}^{\text{columnKernelSize}-1} (\text{intermediate}[i + k, j] \star \text{pColumnKernel}[k])
\]

and for floating point data:

\[
\text{intermediate}[i][j] = \sum_{k=0}^{\text{rowKernelSize}-1} (\text{pSrc}[i, j + k - \text{xAnchor}] \star \text{pRowKernel}[k])
\]
Here $j = 0, \ldots, roiSize.width - 1, i = 0, \ldots, roiSize.height - 1$. The values of pixels of the source image that lies outside of the image ROI (that is, if for pixel $pSrc[i, l] \notin [0, \text{roiSize.width}-1]$) are set in accordance with the specified parameters `borderType` and `borderValue`. 

\[ xAnchor = \frac{(\text{rowKernelSize} - 1)}{2} \]

**Return Values**

- `ippStsNoErr`: Indicates no error. Any other value indicates an error condition.
- `ippStsNullPtrErr`: Indicates an error condition if one of the specified pointers is NULL.
- `ippStsSizeErr`: Indicates an error condition if `roiSize` has a field with a zero or negative value.
- `ippStsStepErr`: Indicates an error condition if the `srcStep` or `dstStep` value is less than `roiSize.width*<pixelSize>`.
- `ippStsNotEvenStepErr`: Indicates an error condition if one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.

**See Also**

Regions of Interest in Intel IPP
User-defined Border Types
FilterSeparableInit  Initializes the filter specification structure.
FilterSeparableGetBufferSize  Computes the size of the work buffer.

**FilterSeparableGetBufferSize**

*Computes the size of the work buffer.*

**Syntax**

```c
IppStatus ippiFilterSeparableGetBufferSize(IppiSize roiSize, IppiSize kernelSize, IppDataType dataType, IppDataType kernelType, int numChannels, int* pBufferSize);
```

Include Files

ippcv.h
ippcv_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- `roiSize` Size of the image ROI in pixels.
kernelSize
Size of the rectangular kernel in pixels.

dataType
Data type of the source image. Possible values are Ipp8u, Ipp16s, Ipp16u, Ipp32f.

kernelType
Data type of the filter kernel. Possible values are Ipp16s and Ipp32f.

numChannels
Number of channels in the image. Possible values are 1, 3, and 4.

pBufferSize
Pointer to the size of the work buffer required for filtering.

Description
This function computes the size of the buffer required for filtering operations. Call this function before using the ippiFilterSeparable function.

Return Values
ippStsNoErr
Indicates no error. Any other value indicates an error.

ippStsNullPtrErr
Indicates an error condition if one of the specified pointers is NULL.

ippStsSizeErr
Indicates an error condition if kernelSize has a field with a zero or negative value.

ippStsDataTypeErr
Indicates an error condition if dataType has an illegal value.

ippStsChannelErr
Indicates an error condition if numChannels has an illegal value.

See Also
FilterSeparable Apply the filter to an image.

FilterSeparableGetSpecSize
Computes the size of the filter specification structure.

Syntax
IppStatus ippiFilterSeparableGetSpecSize(IppiSize kernelSize, IppDataType dataType, int numChannels, int* pSpecSize);
IppStatus ippiFilterSeparableGetSpecSize_L(IppiSize kernelSize, IppDataType dataType, int numChannels, int* pSpecSize);

Include Files
ippcv.h
ippcv_l.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
kernelSize
Size of the rectangular kernel in pixels.
dataType

Data type of the source image. Possible values are Ipp8u, Ipp16s, Ipp16u, Ipp32f.

numChannels

Number of channels in the image. Possible values are 1, 3, and 4.

pSpecSize

Pointer to the size of the filter specification structure.

Description

This function computes the size of the filter specification structure pSpec. Call this function before using theippiFilterSeparableInit function.

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error.

ippStsNullPtrErr

Indicates an error condition if one of the specified pointers is NULL.

ippStsSizeErr

Indicates an error condition if kernelSize has a field with a zero or negative value.

ippStsDataTypeErr

Indicates an error condition if dataType has an illegal value.

ippStsChannelErr

Indicates an error condition if numChannels has an illegal value.

See Also

FilterSeparableInit Initializes the filter specification structure.

FilterSeparableInit

Initializes the filter specification structure.

Syntax

IppStatus ippiFilterSeparableInit_16s(const Ipp16s* pRowKernel, const Ipp16s* pColumnKernel, IppiSize kernelSize, int divisor, int scaleFactor, IppDataType dataType, int numChannels, IppiFilterSeparableSpec* pSpec);

IppStatus ippiFilterSeparableInit_32f(const Ipp32f* pRowKernel, const Ipp32f* pColumnKernel, IppiSize kernelSize, IppDataType dataType, int numChannels, IppiFilterSeparableSpec* pSpec);

Platform-aware functions

IppStatus ippiFilterSeparableInit_16s_L(const Ipp16s* pRowKernel, const Ipp16s* pColumnKernel, IppiSize kernelSize, int divisor, int scaleFactor, IppDataType dataType, int numChannels, IppiFilterSeparableSpec* pSpec);

IppStatus ippiFilterSeparableInit_32f_L(const Ipp32f* pRowKernel, const Ipp32f* pColumnKernel, IppiSize kernelSize, IppDataType dataType, int numChannels, IppiFilterSeparableSpec* pSpec);

Include Files

ippcv.h
ippcv_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- **pRowKernel, pColumnKernel**: Pointer to the row and column kernel values.
- **kernelSize**: Size of the rectangular kernel in pixels.
- **divisor**: Integer value by which the computed result is divided.
- **scaleFactor**: Integer value by which the computed result is divided.
- **dataType**: Data type of the source image. Possible values are Ipp8u, Ipp16s, Ipp16u, Ipp32f.
- **numChannels**: Number of channels in the image. Possible values are 1, 3, and 4.
- **pSpec**: Pointer to the filter specification structure.

Description

This function initializes the filter specification structure `pSpec` in the external buffer. Before using this function, you need to compute the size of the specification structure using the `FilterSeparableGetSpecSize` function. This structure is used by the `FilterSeparable` function that performs filtering operations on the source image pixels.

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if `kernelSize` has a field with a zero or negative value.
- **ippStsDataTypeErr**: Indicates an error condition if `dataType` has an illegal value.
- **ippStsChannelErr**: Indicates an error condition if `numChannels` has an illegal value.
- **ippStsDivisorErr**: Indicates an error condition if `divisor` has a zero value.

See Also

- **FilterSeparable**  Apply the filter to an image.
- **FilterSeparableGetSpecSize**  Computes the size of the filter specification structure.

Wiener Filters

Intel IPP functions described in this section perform adaptive noise-removal filtering of an image using Wiener filter [Lim90]. The adaptive filter is more selective than a comparable linear filter in preserving edges and other high frequency parts of an image. Wiener filters are commonly used in image processing applications to remove additive noise from degraded images, to restore a blurry image, and in similar operations.

These functions use a pixel-wise adaptive Wiener method based on statistics estimated from a local neighborhood (mask) of arbitrary size for each pixel.
**FilterWienerGetBufferSize**

*Computes the size of the external buffer for ippiFilterWiener function.*

**Syntax**

```c
IppStatus ippiFilterWienerGetBufferSize(IppiSize dstRoiSize, IppiSize maskSize, int channels, int* pBufferSize);
```

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dstRoiSize</td>
<td>Size of the destination ROI in pixels.</td>
</tr>
<tr>
<td>maskSize</td>
<td>Size of the mask in pixels.</td>
</tr>
<tr>
<td>channels</td>
<td>Number of channels in the image.</td>
</tr>
<tr>
<td>pBufferSize</td>
<td>Pointer to the computed value of the external buffer size.</td>
</tr>
</tbody>
</table>

**Description**

This function computes the size in bytes of an external memory buffer that is required for the function `ippiFilterWiener`, and stores the result in the `pBufferSize`.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**: Indicates an error condition if the `pBufferSize` pointer is NULL.
- **ippStsSizeErr**: Indicates an error condition if one of the fields of `dstRoiSize` has a zero or negative value.
- **ippStsMaskSizeErr**: Indicates an error condition if one of the fields of `maskSize` has a value less than or equal to 1.
- **ippStsNumChannelsErr**: Indicates an error condition if `channels` is not 1, 3 or 4.

**FilterWiener**

*Filters an image using the Wiener algorithm.*
Syntax

Case 1: Operation on one-channel images

IppStatus ippiFilterWiener_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiPoint anchor, Ipp32f noise[1], Ipp8u* pBuffer);

Supported values for mod:

- 8u_C1R
- 16s_C1R
- 32f_C1R

Case 2: Operation on multi-channel images

IppStatus ippiFilterWiener_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiPoint anchor, Ipp32f noise[3], Ipp8u* pBuffer);

Supported values for mod:

- 8u_C3R
- 16s_C3R
- 32f_C3R
- 8u_AC4R
- 16s_AC4R
- 32f_AC4R

IppStatus ippiFilterWiener_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiSize maskSize, IppiPoint anchor, Ipp32f noise[4], Ipp8u* pBuffer);

Supported values for mod:

- 8u_C4R
- 16s_C4R
- 32f_C4R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc
srcStep
pDst
dstStep
dstRoiSize
maskSize
anchor
noise
pBuffer

- Pointer to the source image ROI.
- Distance in bytes between starts of consecutive lines in the source image.
- Pointer to the destination image ROI.
- Distance in bytes between starts of consecutive lines in the destination image.
- Size of the source and destination ROI in pixels.
- Size of the mask in pixels.
- Anchor cell specifying the mask alignment with respect to the position of the input pixel.
- Noise level value or array of the noise level values in case of multi-channel image. This value must be in the range [0,1].
- Pointer to the external work buffer.
Description

This function operates with ROI (see Regions of Interest in Intel IPP). This function performs adaptive filtering of the image degraded by constant power additive noise. For each pixel of the input image $pSrc$, the function estimates the local image mean $\mu$ and variance $\sigma$ in the rectangular neighborhood (mask) of size $maskSize$ with the anchor cell $anchor$ centered on the pixel. The anchor cell is specified by its coordinates $anchor.x$ and $anchor.y$ in the coordinate system associated with the bottom right corner of the mask.

The following formulas are used in computations:

$$
\mu_{i,j} = \frac{1}{HW} \cdot \sum_{m=0}^{H-1} \sum_{n=0}^{W-1} x_{m,n}
$$

$$
\sigma_{i,j}^2 = \frac{1}{HW} \cdot \sum_{m=0}^{H-1} \sum_{n=0}^{W-1} x_{m,n}^2 - \mu_{i,j}^2
$$

Here $\mu_{i,j}$ and $\sigma_{i,j}$ stand for local mean and variance for pixel $X_{i,j}$, respectively, and $H$, $W$ are the vertical and horizontal sizes of the mask, respectively.

The corresponding value for the output pixel $Y_{i,j}$ is computed as:

$$
Y_{i,j} = \mu_{i,j} + \frac{\sigma_{i,j}^2 - \nu^2}{\sigma^2} \cdot [X_{i,j} - \mu_{i,j}]
$$

and stored in the $pDst$. Here $\nu^2$ is the noise variance, specified for each channel by the noise level parameter $noise$. If this parameter is not defined ($noise = 0$), then the function estimates the noise level by averaging through the image of all local variances $\sigma_{i,j}$, and stores the corresponding values in the $noise$ for further use.

The function $ippiFilterWiener$ uses the external work buffer $pBuffer$, which must be allocated before the function call. To determine the required buffer size, the function $ippiFilterWienerGetBufferSize$ can be used.
Figure “Applying the function ippiFilterWiener” illustrates the result of using ippiFilterWiener_32f_C1R function.

**Applying the function ippiFilterWiener**

Return Values

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error condition if one of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error condition if one of the fields of dstRoiSize has a zero or negative value.</td>
</tr>
<tr>
<td>ippStsMaskSizeErr</td>
<td>Indicates an error condition if one of the fields of maskSize has a value less than or equal to 1.</td>
</tr>
<tr>
<td>ippStsNoiseRangeErr</td>
<td>Indicates an error condition if one of the noise values is less than 0 or greater than 1.</td>
</tr>
</tbody>
</table>

**Example**

To better understand usage of this function, refer to the FilterWiener.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

**Convolution**

Intel IPP functions described in this section perform two-dimensional finite linear convolution operation between two source images and write the result into the destination image. Convolution is used to perform many common image processing operations including sharpening, blurring, noise reduction, embossing, and edge enhancement. For convenience, any digital image \( f \) is represented here as a matrix with \( M_f \) columns and \( N_f \) rows that contains pixel values \( f[i, j], 0 \leq i < M_f, 0 \leq j < N_f \).
ConvGetBufferSize

Computes the size of the work buffer for the ippiConv function.

Syntax

IppStatus ippiConvGetBufferSize (IppiSize src1Size, IppiSize src2Size, IppDataType dataType, int numChannels, IppEnum algType, int* pBufferSize);

Include Files

ippi.h

Parameters

src1Size, src2Size
Size, in pixels, of the source images.

dataType
Data type for convolution. Possible values are ipp32f, ipp16s, or ipp8u.

numChannels
Number of image channels. Possible values are 1, 3, or 4.

algType
Bit-field mask for the algorithm type definition. Possible values are the results of composition of the IppAlgType and IppiROIShape values.

pBufferSize
Pointer to the size of the work buffer.

Description

The ippiConvGetBufferSize function computes the size, in bytes, of the external work buffer needed for the function that performs two-dimensional convolution. The result is stored in the pBufferSize parameter.

Return Values

ippStsNoErr
Indicates no error.

ippStsSizeErr
Indicates an error when the src1Size or src2Size is negative, or equal to zero.

ippStsNullChannelsErr
Indicates an error when the numChannels value differs from 1, 3, or 4.

ippStsDataTypeErr
Indicates an error when the dataType value differs from the ipp32f, ipp16s, or ipp8u.

ippStsAlgTypeErr
Indicates an error when:

- the result of the bitwise AND operation between algType and ippAlgMask differs from the ippAlgAuto, ippAlgDirect, or ippAlgFFT values;
- the result of the bitwise AND operation between algType and ippiROIMask differs from the ippiROIFull or ippiROIValid values.

ippStsNullPtrErr
Indicates an error when the pBufferSize is NULL.

See Also

Structures and Enumerators

Conv Performs two-dimensional convolution of two images.
**Conv**

Performs two-dimensional convolution of two images.

**Syntax**

**Case 1: Operating on integer data**

IppStatus ippiConv_<mod>(const Ipp<datatype>* pSrc1, int src1Step, IppiSize src1Size, const Ipp<datatype>* pSrc2, int src2Step, IppiSize src2Size, Ipp<datatype>* pDst, int dstStep, int divisor, IppEnum algType, Ipp8u* pBuffer);

Supported values for **mod**

8u_C1R  16s_C1R  8u_C3R  16s_C3R  8u_C4R  16s_C4R

**Case 2: Operating on floating-point data**

IppStatus ippiConv_<mod>(const Ipp32f* pSrc1, int src1Step, IppiSize src1Size, const Ipp32f* pSrc2, int src2Step, IppiSize src2Size, Ipp32f* pDst, int dstStep, IppEnum algType, Ipp8u* pBuffer);

Supported values for **mod**

32f_C1R  32f_C3R  32f_C4R

**Include Files**
ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **pSrc1, pSrc2**
  - Pointers to the source images ROI.
- **src1Step, src2Step**
  - Distance, in bytes, between the starting points of consecutive lines in the source images.
- **src1Size, src2Size**
  - Size in pixels of the source images.
- **pDst**
  - Pointer to the destination image ROI.
- **dstStep**
  - Distance, in bytes, between the starting points of consecutive lines in the destination image.
- **divisor**
  - The integer value by which the computed result is divided (for operations on integer data only).
- **algType**
  - Bit-field mask for the algorithm type definition. Possible values are the results of composition of the IppAlgType and IppiROIShape values.
- **pBuffer**
  - Pointer to the buffer for internal calculations.
Description

Before using this function, you need to compute the size of the work buffer using the ippiConvGetBufferSize function.

The ippiConv function operates with ROI. The type of convolution that function performs is defined by the value of the algType parameter:

1. If the ippiROIFull flag is set, the function performs full two-dimensional finite linear convolution between two source images pointed by the pSrc1 and pSrc2 parameters. The resulting destination image \( h[i, j] \) is computed by the following formula:

\[
h[i, j] = \frac{1}{\text{divisor}} \sum_{k=0}^{M_f-1} \sum_{l=0}^{M_g-1} f[k, l] \times g[i-k, j-l],
\]

where
- \( M_h = M_f + M_g - 1 \)
  where
  - \( M_f \) is the number of rows in the first source image matrix \( f \)
  - \( M_g \) is the number of rows in the second source image matrix \( g \)
  - \( N_h = N_f + N_g - 1 \)
  where
  - \( N_f \) is the number of columns in the first source image matrix \( f \)
  - \( N_g \) is the number of columns in the second source image matrix \( g \)
  - \( 0 \leq i < M_h, 0 \leq i < N_h \)
  - \( f[k, l] = \begin{cases} f[k, l], & 0 \leq k < M_f, \quad 0 \leq l < N_f \\ 0, & \text{otherwise} \end{cases} \)

\( g[i-k, j-l] = \begin{cases} g[i-k, j-l], & 0 \leq i-k < M_g, \quad 0 \leq j-l < N_g \\ 0, & \text{otherwise} \end{cases} \)

2. If the ippiROIValid flag is set up, the function performs valid two-dimensional finite linear convolution between two source images pointed by the pSrc1 and pSrc2 parameters. The destination image \( h[i, j] \) obtained as a result of the function operation is computed by the following formula:

\[
h[i, j] = \frac{1}{\text{divisor}} \sum_{k=0}^{M_g-1} \sum_{l=0}^{M_g-1} f[i+k, j+l] \times g[M_g-k-1, N_g-l-1],
\]

where
- \( M_h = |M_f - M_g| + 1 \)
  where
  - \( M_f \) is the number of rows in the first source image matrix \( f \)
  - \( M_g \) is the number of rows in the second source image matrix \( g \)
\[ N_h = |N_f - N_g| + 1 \]

where
- \( N_f \) is the number of columns in the first source image matrix \( f \)
- \( N_g \) is the number of columns in the second source image matrix \( g \)
- \( 0 \leq i < M_h, 0 \leq i < N_h \)

This case assumes that \( M_f \geq M_g \) and \( N_f \geq N_g \). In case when \( M_f < M_g \) and \( N_f < N_g \), the subscript index \( g \) in this equation must be replaced with the index \( f \). For any other combination of source image sizes, the function performs no operation.

**NOTE**
The above formula provides the same result as in the case with the ippiROIFull flag, but produces only the part of the convolution image that is computed without zero-padded values.

Function flavors that accept input data of the Ipp32f type use the same summation formula, but without scaling of the result (\( \text{divisor} = 1 \) is assumed).

The following examples illustrate the function operation. For the source images \( f, g \) of size 3 x 5 represented as

\[
\begin{bmatrix}
1 & 1 & 1 \\
1 & 0 & 0 \\
1 & 1 & 1 \\
0 & 0 & 1 \\
1 & 1 & 1
\end{bmatrix}, \quad g = f
\]

with \( g = f \):
- for the ippiROIFull case, the resulting convolution image \( h \) is of size 5 x 9 and contains the following data:

\[
\begin{bmatrix}
1 & 2 & 3 & 2 & 1 \\
2 & 2 & 2 & 0 & 0 \\
3 & 4 & 6 & 4 & 2 \\
2 & 2 & 4 & 2 & 2 \\
3 & 6 & 1 & 1 & 6 & 3 \\
2 & 2 & 4 & 2 & 2 \\
2 & 4 & 6 & 4 & 3 \\
0 & 0 & 2 & 2 & 2 \\
1 & 2 & 3 & 2 & 1
\end{bmatrix}
\]
- for the ippiROIValid case, the resulting convolution image \( h \) is of size 1 x 1 and contains the following data:

\[ h = [11] \]
Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**: Indicates an error when any of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error when `src1Size` or `src2Size` has a zero or negative value.
- **ippStsStepErr**: Indicates an error when `src1Step`, `src2Step`, or `dstStep` has a zero or negative value.
- **ippStsDivisorErr**: Indicates an error when `divisor` has a zero value.
- **ippStsAlgTypeErr**: Indicates an error when:
  - the result of the bitwise AND operation between the `algType` and `ippAlgMask` differs from the `ippAlgAuto`, `ippAlgDirect`, or `ippAlgFFT` values;
  - the result of the bitwise AND operation between the `algType` and `ippiROIMask` differs from the `ippiROIFull` or `ippiROIValid` values.

Example

To better understand usage of this function, refer to the `Conv.c` example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

See Also

- Regions of Interest in Intel IPP
- Structures and Enumerators
- ConvGetBufferSize Computes the size of the work buffer for the `ippiConv` function.

Deconvolution

Functions described in this section perform image deconvolution. They can be used for restoring the degraded image, in particular image that was obtained by applying the convolution operation with known kernel. The Intel IPP functions implement two methods: the Fourier deconvolution (noniterative method) [see for example, [Puetter05]], and the Richardson-Lucy method (iterative method) [Ric72]. Border pixels of a source image are restored before deconvolution.

**DeconvFFTGetSize**

*Computes the size of the state structure for deconvolution with the fast Fourier transform (FFT).*

**Syntax**

```c
IppStatus ippiDeconvFFTGetSize_32f(int nChannels, int kernelSize, int FFTorder, int* pSize);
```

**Include Files**

- ippi.h

**Domain Dependencies**

- **Headers**: ippcore.h, ippvm.h, ipps.h
- **Libraries**: ippcore.lib, ippvm.lib, ipps.lib
**Parameters**

- **nChannels**
  - Number of channels in the image. Possible values are 1 or 3.

- **kernelSize**
  - Size of the kernel.

- **FFTorder**
  - Order of the created FFT state structure.

- **pSize**
  - Pointer to the size of the `IppiDeconvFFTState_32f_C1R` or `IppiDeconvFFTState_32f_C3R` structure, in bytes.

**Description**

This function computes the fast Fourier transform (FFT) deconvolution state structure size that is required to initialize the structure with the `ippiDeconvFFTInit` function. This structure is used by the `ippiDeconvFFT` function, which performs deconvolution of the source image using FFT.

**Return Values**

- **ippStsNoErr**
  - Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**
  - Indicates an error when any of the specified pointers is `NULL`.

- **ippStsNumChannelsErr**
  - Indicates an error when `nChannels` has an illegal value.

- **ippStsSizeErr**
  - Indicates an error when `kernelSize` is less than, or equal to 0; or if `kernelSize` is greater than $2^{FFTorder}$.

**See Also**

- **DeconvFFTInit**  Initializes the FFT deconvolution state structure.
- **DeconvFFT**  Performs FFT deconvolution of an image.

**DeconvFFTInit**

*Initializes the FFT deconvolution state structure.*

**Syntax**

```c
IppStatus ippiDeconvFFTInit_32f_C1R(IppiDeconvFFTState_32f_C1R* pDeconvFFTState, const Ipp32f* pKernel, int kernelSize, int FFTorder, Ipp32f threshold);
IppStatus ippiDeconvFFTInit_32f_C3R(IppiDeconvFFTState_32f_C3R* pDeconvFFTState, const Ipp32f* pKernel, int kernelSize, int FFTorder, Ipp32f threshold);
```

**Include Files**

ippi.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **pDeconvFFTState**
  - Pointer to the FFT deconvolution state structure.

- **pKernel**
  - Pointer to the kernel array.

- **kernelSize**
  - Size of the kernel.
**FFTorder**
Order of the created FFT state structure.

**threshold**
Value of the threshold level (to exclude dividing by zero).

**Description**
This function initializes the FFT deconvolution state structure that is used by the `ippiDeconvFFT` function to perform deconvolution of the source image using FFT. Before using the `ippiDeconvFFTInit` function, compute the size of the structure using the `ippiDeconvFFTGetSize` function.

**Return Values**
- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when any of the specified pointers is `NULL`.
- **ippStsSizeErr**: Indicates an error when `kernelSize` is less than, or equal to 0; or if `kernelSize` is greater than $2^{FFTorder}$.
- **ippStsBadArgErr**: Indicates an error when `threshold` is less than, or equal to 0.

**See Also**
- **DeconvFFTGetSize**: Computes the size of the state structure for deconvolution with the fast Fourier transform (FFT).
- **DeconvFFT**: Performs FFT deconvolution of an image.

**DeconvFFT**
Performs FFT deconvolution of an image.

**Syntax**
```
IppStatus ippiDeconvFFT_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiDeconvFFTState_32f_C1R* pDeconvFFTState);
IppStatus ippiDeconvFFT_32f_C3R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiDeconvFFTState_32f_C3R* pDeconvFFTState);
```

**Include Files**
`ippi.h`

**Domain Dependencies**
Headers: `ippcore.h`, `ippvm.h`, `ipps.h`
Libraries: `ippcore.lib`, `ippvm.lib`, `ipps.lib`

**Parameters**
- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**: Size of the source and destination image ROI.
pDeconvFFTState

Pointer to the FFT deconvolution state structure.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function performs deconvolution of the source image pSrc using FFT with parameters specified in the FFT deconvolution state structure pDeconvFFTState and stores results to the destination image pDst. The FFT deconvolution state structure must be initialized by calling the function DeconvFFTInit beforehand.

Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error condition if one of the specified pointers is NULL.

DeconvLRGetSize

Computes the size of the state structure for Lucy-Richardson (LR) deconvolution.

Syntax
IppStatus ippiDeconvLRGetSize_32f(int numChannels, int kernelSize, IppiSize maxRoi, int* pSize);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

numChannels Number of channels in the image. Possible values are 1 or 3.
kernellSize Size of the kernel.
maxRoi Maximum size of the image ROI, in pixels.
pSize Pointer to the size of the IppiDeconvLRState_32f_C1R or IppiDeconvLRState_32f_C3R structure, in bytes.

Description
This function computes the Lucy-Richardson (LR) deconvolution state structure size that is required to initialize the structure with the ippiDeconvLRInit function. This structure is used by the ippiDeconvLR function, which performs LR deconvolution of the source image.

Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error when any of the specified pointers is NULL.
Indicates an error when:

- `kernelSize` is less than, or equal to 0
- `kernelSize` is greater than `maxRoi.height` or `maxRoi.width`
- `maxRoi.height` or `maxRoi.width` is less than, or equal to zero

See Also

DeconvLRInit  Initializes the LR deconvolution state structure.
DeconvLR  Performs LR deconvolution of an image.

**DeconvLRInit**

*Initializes the LR deconvolution state structure.*

**Syntax**

```c
IppStatus ippiDeconvLRInit_32f_C1R(IppiDeconvLR_32f_C1R* pDeconvLR, const Ipp32f* pKernel, int kernelSize, IppiSize maxRoi, Ipp32f threshold);
IppStatus ippiDeconvLRInit_32f_C3R(IppiDeconvLR_32f_C3R* pDeconvLR, const Ipp32f* pKernel, int kernelSize, IppiSize maxRoi, Ipp32f threshold);
```

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- `pDeconvLR`  
  Pointer to the LR deconvolution state structure.
- `pKernel`  
  Pointer to the kernel array.
- `kernelSize`  
  Size of the kernel.
- `maxRoi`  
  Maximum size of the image ROI, in pixels.
- `threshold`  
  Value of the threshold level (to exclude dividing by zero).

**Description**

This function initializes the LR deconvolution state structure that is used by the `ippiDeconvLR` function to perform LR deconvolution of the source image. Before using the `ippiDeconvLRInit` function, compute the size of the structure using the `ippiDeconvLRGetSize` function.

**Return Values**

- `ippStsNoErr`  
  Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr`  
  Indicates an error when any of the specified pointers is NULL.
- `ippStsSizeErr`  
  Indicates an error when:
  - `kernelSize` is less than, or equal to 0
  - `kernelSize` is greater than `maxRoi.height` or `maxRoi.width`
maxRoi.height or maxRoi.width is less than, or equal to zero

Indicates an error when threshold is less than, or equal to 0.

See Also
DeconvLRGetSize Computes the size of the state structure for Lucy-Richardson (LR) deconvolution.
DeconvLR Performs LR deconvolution of an image.

DeconvLR
Performs LR deconvolution of an image.

Syntax
IppStatus ippiDeconvLR_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, int numIter, IppiDeconvLR_32f_C1R* pDeconvLR);
IppStatus ippiDeconvLR_32f_C3R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, int numIter, IppiDeconvLR_32f_C3R* pDeconvLR);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pSrc Pointer to the source image ROI.
srcStep Distance in bytes between starts of consecutive lines in the source image.
pDst Pointer to the destination image ROI.
dstStep Distance in bytes between starts of consecutive lines in the destination image.
roiSize Size of the source and destination image ROI.
numIter Number of algorithm iterations.
pDeconvLR Pointer to the LR deconvolution state structure.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function performs deconvolution of the source image pSrc using the Lucy-Richardson algorithm with parameters specified in the state structure pDeconvLR and stores results to the destination image pDst. The Lucy-Richardson deconvolution state structure must be initialized by calling the function DeconvLRInit beforehand.
Return Values

ippStsNoErr  Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  Indicates an error condition if one of the specified pointers is NULL.

ippStsSizeErr  Indicates an error condition if roi.width or roi.height is less than or equal to 0, or if roi.width is greater than (maxRoi.width - kernelSize), or roi.height is greater than (maxRoi.height - kernelSize).

ippStsStepErr  Indicates an error condition if srcStep or dstStep is less than roiSize.width * <pixelSize>.

ippStsNotEvenStepErr  Indicates an error condition if steps for floating-point images are not divisible by 4.

ippStsBadArgErr  Indicates an error condition if numIter is less than or equal to 0.

Fixed Filters

The fixed filter functions perform linear filtering of a source image using one of the predefined convolution kernels. The supported fixed filters and their respective kernel sizes are listed in the following table:

Types of the Fixed Filter Functions

<table>
<thead>
<tr>
<th>Fixed Filter Type</th>
<th>Kernel Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horizontal Prewitt operator</td>
<td>3x3</td>
</tr>
<tr>
<td>Vertical Prewitt operator</td>
<td>3x3</td>
</tr>
<tr>
<td>Horizontal Scharr operator</td>
<td>3x3</td>
</tr>
<tr>
<td>Vertical Scharr operator</td>
<td>3x3</td>
</tr>
<tr>
<td>Horizontal Sobel operator</td>
<td>3x3 or 5x5</td>
</tr>
<tr>
<td>Vertical Sobel operator</td>
<td>3x3 or 5x5</td>
</tr>
<tr>
<td>Second derivative horizontal Sobel operator</td>
<td>3x3 or 5x5</td>
</tr>
<tr>
<td>Second derivative vertical Sobel operator</td>
<td>3x3 or 5x5</td>
</tr>
<tr>
<td>Second cross derivative Sobel operator</td>
<td>3x3 or 5x5</td>
</tr>
<tr>
<td>Horizontal Roberts operator</td>
<td>3x3</td>
</tr>
<tr>
<td>Vertical Roberts operator</td>
<td>3x3</td>
</tr>
<tr>
<td>Laplacian highpass filter</td>
<td>3x3 or 5x5</td>
</tr>
<tr>
<td>Gaussian lowpass filter</td>
<td>3x3 or 5x5</td>
</tr>
<tr>
<td>Highpass filter</td>
<td>3x3 or 5x5</td>
</tr>
<tr>
<td>Lowpass filter</td>
<td>3x3 or 5x5</td>
</tr>
<tr>
<td>Sharpening filter</td>
<td>3x3</td>
</tr>
</tbody>
</table>

Using fixed filter functions with predefined kernels is more efficient as it eliminates the need to create the convolution kernel in your application program.

NOTE
The anchor cell is the center cell of the kernel for all fixed filters.
FilterGaussianGetBufferSize

Computes the size of the Gaussian specification structure and the size of the external work buffer for Gaussian filtering with user-defined borders.

Syntax

IppStatus ippiFilterGaussianGetBufferSize(IppiSize maxRoiSize, Ipp32u kernelSize, IppDataType dataType, int numChannels, int* pSpecSize, int* pBufferSize);

Platform-aware functions

IppStatus ippiFilterGaussianGetBufferSize_L(IppiSizeL maxRoiSize, int kernelSize, IppDataType dataType, IppiBorderType borderType, int numChannels, IppSizeL* pBufferSize);

Include Files

ippcv.h

Flavors with the _L suffix: ippcv_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

maxRoiSize

Maximal size of the image ROI in pixels.

kernelSize

Size of the Gaussian filter kernel. The value must be odd and greater, or equal to 3.

dataType

Data type of the source and destination images.

borderType

One of border supported types.

numChannels

Number of channels in the images. Possible values are 1 and 3.

pSpecSize

Pointer to the computed size (in bytes) of the Gaussian specification structure.

pBufferSize

Pointer to the computed size (in bytes) of the external buffer.

Description

This function computes the size of the Gaussian context structure and external work buffer for the FilterGaussianBorder function or for the platform-aware function FilterGaussian. The results are stored in pSpecSize and pBufferSize. The buffer with the length pBufferSize[0] can be used to filter an image with the width and height less than, or equal to the corresponding fields of maxRoiSize, and/or kernel size that is less than, or equal to kernelSize.

NOTE

The platform-aware function FilterGaussianGetBufferSize_L computes only the size of the external work buffer for Gaussian filtering with user-defined borders. To compute the size of the Gaussian specification structure, please use the platform-aware function FilterGaussianGetSpecSize.
Use the computed \texttt{pBufferSize} and \texttt{pSpecSize} values to allocate the memory using the \texttt{ippMalloc} or \texttt{ippsMalloc} functions. The allocated memory can be freed only by the \texttt{ippFree} or \texttt{ippsFree} functions, respectively. For more information about the memory allocation functions, refer to the "Support Functions" section of the \textit{Intel IPP Developer Reference, vol. 1}.

For an example on how to use this function, refer to the example provided with the \texttt{FilterGaussianBorder} function description.

**Return Values**

- \texttt{ippStsNoErr} Indicates no error. Any other value indicates an error.
- \texttt{ippStsNullPtrErr} Indicates an error when one of the specified pointers is \texttt{NULL}.
- \texttt{ippStsSizeErr} Indicates an error when \texttt{maxRoiSize} has a field with a zero or negative value.
- \texttt{ippStsBadArgErr} Indicates an error when \texttt{kernelSize} is even, or less than 3.
- \texttt{ippStsDataTypeErr} Indicates an error when \texttt{dataType} has an illegal value.
- \texttt{ippStsNumChannelErr} Indicates an error when \texttt{numChannels} has an illegal value.

**See Also**

- \texttt{FilterGaussianBorder} Performs Gaussian filtering of an image with user-defined borders.

**FilterGaussianGetSpecSize**

*Computes the size of the Gaussian specification structure.*

**Syntax**

\begin{verbatim}
IppStatus ippiFilterGaussianGetSpecSize(int kernelSize, IppDataType dataType, int numChannels, int* pSpecSize, int* pInitBufferSize);
IppStatus ippiFilterGaussianGetSpecSize_L(int kernelSize, IppDataType dataType, int numChannels, IppSizeL* pSpecSize, IppSizeL* pInitBufferSize);
\end{verbatim}

**Include Files**

\begin{verbatim}
ippcv.h
ippcv_l.h
\end{verbatim}

**Domain Dependencies**

- **Headers**: ippcore.h, ippvm.h, ipps.h,ippi.h
- **Libraries**: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- \texttt{kernelSize} Size of the Gaussian filter kernel. The value must be odd and greater, or equal to 3.
- \texttt{dataType} Data type of the source and destination images.
- \texttt{numChannels} Number of channels in the images. Possible values are 1 and 3.
- \texttt{pSpecSize} Pointer to the computed size (in bytes) of the Gaussian specification structure.
pInitBufferSize

Pointer to the computed size (in bytes) of the external buffer.

Description

This function computes the size of the Gaussian context structure and the size of the initialization external work buffer for the FilterGaussianBorder function or for the platform-aware functions FilterGaussianInit and FilterGaussian. The results are stored in pSpecSize and pInitBufferSize. The buffer with the length pInitBufferSize[0] can be used to initialize the specification structure for the Gaussian filter.

Use the computed pInitBufferSize and pSpecSize values to allocate the memory using the ippMalloc or ippsMalloc functions. The allocated memory can be freed only by the ippFree or ippsFree functions, respectively. For more information about the memory allocation functions, refer to the "Support Functions" section of the Intel IPP Developer Reference, vol. 1.

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error.

ippStsNullPtrErr

Indicates an error when one of the specified pointers is NULL.

ippStsBadArgErr

Indicates an error when kernelSize is even, or less than 3.

ippStsDataTypeErr

Indicates an error when dataType has an illegal value.

ippStsNumChannelErr

Indicates an error when numChannels has an illegal value.

See Also

FilterGaussian  Performs Gaussian filtering of an image with user-defined borders.

FilterGaussianInit

 Initializes the Gaussian context structure.

Syntax

IppStatus ippiFilterGaussianInit(IppSize roiSize, Ipp32u kernelSize, Ipp32f sigma, IppiBorderType borderType, IppDataType dataType, int numChannels, IppFilterGaussianSpec* pSpec, Ipp8u* pBuffer);

Platform-aware functions

IppStatus ippiFilterGaussianInit_L(IppSizeL roiSize, int kernelSize, Ipp32f sigma, IppiBorderType borderType, IppDataType dataType, int numChannels, IppFilterGaussianSpec* pSpec, Ipp8u* pInitBuffer);

Include Files

ippcv.h

Flavors with the _L suffix: ippcv_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
**Parameters**

- `roiSize`  
  Size of the image ROI in pixels.

- `kernelSize`  
  Size of the Gaussian filter kernel. The value must be odd and greater, or equal to 3.

- `sigma`  
  Standard deviation of the Gaussian kernel.

- `borderType`  
  Type of border. Possible values are:
  - `ippBorderConst`  
    Values of all border pixels are set to constant.
  - `ippBorderRepl`  
    Border is replicated from the edge pixels.
  - `ippBorderInMem`  
    Border is obtained from the image pixels in memory.
  - `ippBorderMirror`  
    Border pixels are mirrored from the source image boundary pixels.

- `dataType`  
  Data type of the source and destination images.

- `numChannels`  
  Number of channels in the images. Possible values are 1 and 3.

- `pSpec`  
  Pointer to the Gaussian specification structure.

- `pBuffer`, `pInitBuffer`  
  Pointer to the external buffer.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function initializes the Gaussian specification structure `pSpec` for the `FilterGaussianBorder` function or for the platform-aware function `FilterGaussian`. Before using this function, compute the size of the specification structure and the external buffer using the `FilterGaussianGetBufferSize` function and `FilterGaussianGetSpecSize` for the platform-aware function.

The `roiSize` and `kernelSize` values must be less than, or equal to the corresponding values specified in the `FilterGaussianGetBufferSize` function.

The kernel of the Gaussian filter is the matrix of size `kernelSize x kernelSize` with the standard deviation `sigma`. The values of the Gaussian kernel elements are calculated by the formula below and then normalized:

\[
G(i, j) = \exp \left\{ -\frac{(K/2 - i)^2 + (K/2 - j)^2}{2\sigma^2} \right\}, \quad i, j = 0, \ldots, K
\]

The anchor cell is the center of the kernel.

For an example on how to use this function, refer to the example provided with the `FilterGaussianBorder` function description.

**Return Values**

- `ippStsNoErr`  
  Indicates no error. Any other value indicates an error.
Indicates an error when one of the specified pointers is NULL.

Indicates an error when \texttt{roiSize} has a field with a zero or negative value.

Indicates an error when \texttt{kernelSize} is even, or less than 3; or \texttt{sigma} is less than, or equal to zero.

Indicates an error when \texttt{dataType} has an illegal value.

Indicates an error when \texttt{numChannels} has an illegal value.

Indicates an error when \texttt{borderType} has an illegal value.

**See Also**

- **FilterGaussianGetBufferSize** Computes the size of the Gaussian specification structure and the size of the external work buffer for Gaussian filtering with user-defined borders.
- **FilterGaussianBorder** Performs Gaussian filtering of an image with user-defined borders.

**FilterGaussian**

*Performs Gaussian filtering of an image with user-defined borders.*

**Syntax**

**Case 1: Operating on one-channel data**

\[
\text{IppStatus ippiFilterGaussian\_<mod>(const Ipp<datatype>* psRC, int srcStep, Ipp<datatype>* pDst, int dstStep, IppSize roiSize, IppiBorderType borderType, const Ipp<datatype> borderValue[1], IppFilterGaussianSpec* pSpec, Ipp8u* pBuffer)};
\]

Supported values for \texttt{mod}:

- 8u\_C1R
- 16u\_C1R
- 16s\_C1R
- 32f\_C1R

**Case 2: Operating on multi-channel data**

\[
\text{IppStatus ippiFilterGaussian\_<mod>(const Ipp<datatype>* psRC, int srcStep, Ipp<datatype>* pDst, int dstStep, IppSize roiSize, IppiBorderType borderType, const Ipp<datatype> borderValue[3], IppFilterGaussianSpec* pSpec, Ipp8u* pBuffer)};
\]

Supported values for \texttt{mod}:

- 8u\_C3R
- 16u\_C3R
- 16s\_C3R
- 32f\_C3R

**Case 3: Operating on one-channel data with platform-aware functions**

\[
\text{IppStatus ippiFilterGaussian\_<mod>(const Ipp<datatype>* psRC, IppSizeL srcStep, Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, IppiBorderType borderType, const Ipp<datatype> borderValue[1], IppFilterGaussianSpec* pSpec, Ipp8u* pBuffer)};
\]

Supported values for \texttt{mod}:

- 8u\_C1R\_L
- 16u\_C1R\_L
- 16s\_C1R\_L
- 32f\_C1R\_L
Case 4: Operating on multi-channel data with platform-aware functions

IppStatus ippiFilterGaussian_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep,
Ipp<datatype>* pDst, IppSizeL dstStep, IppSizeL roiSize, IppBorderType borderType,
const Ipp<datatype> borderValue[3], IppFilterGaussianSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:
8u_C3R_L  16u_C3R_L  16s_C3R_L  32f_C3R_L

Include Files
ippcv.h
ippcv_l.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc Pointer to the source image ROI.
srcStep Distance, in bytes, between the starting points of consecutive lines in the source image.
pDst Pointer to the destination image ROI.
dstStep Distance, in bytes, between the starting points of consecutive lines in the destination image.
roiSize Size of the source and destination image ROI, in pixels.
borderType One of the supported border types.
borderValue Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.
pSpec Pointer to the Gaussian specification structure.
pBuffer Pointer to the work buffer.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
These functions apply the Gaussian filter to the source image ROI pSrc. The kernel of the Gaussian filter is the matrix of size kernelSize x kernelSize with the standard deviation sigma. The values of the Gaussian kernel elements are computed by the FilterGaussianInit function. Elements of the kernel are normalized. The anchor cell is the center of the kernel.
Before using the ippiFilterGaussian function, compute the size of the Gaussian specification structure using the FilterGaussianGetSpecSize function and the external buffer using the FilterGaussianGetBufferSize function and initialize the structure using the FilterGaussianInit function.

Return Values

ippStsNoErr Indicates no error.
Indicates an error when one of the specified pointers is NULL.
Indicates an error when roiSize has a field with a zero or negative value.
Indicates an error when srcStep or dstStep is less than roiSize.width*pixelSize.
Indicates an error when one of the step values is not divisible by sizeof(Ipp<dataType>).
Indicates an error when borderType has an illegal value.
Indicates an error when kernelSize is even, or less than 3.

Example
To better understand usage of this function, refer to the FilterGaussianBorder.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

See Also
Regions of Interest in Intel IPP
User-defined Border Types
FilterGaussianGetSpecSize  Computes the size of the Gaussian specification structure.
FilterGaussianGetBufferSize  Computes the size of the Gaussian specification structure and the size of the external work buffer for Gaussian filtering with user-defined borders.
FilterGaussianInit  Initializes the Gaussian context structure.

FilterHipassBorderGetBufferSize
Computes the size of the work buffer for high-pass filtering with the ippiFilterHipassBorder function.

Syntax
IppStatus ippiFilterHipassBorderGetBufferSize(IppiSize dstRoiSize, IppiMaskSize mask, IppDataType srcDataType, IppDataType dstDataType, int numChannels, int* pBufferSize);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
dstRoiSize  Size of the destination ROI, in pixels.
mask  Predefined mask of IppiMaskSize type. Possible values are: ippMskSize3x3 or ippMskSize5x5.
srcDataType  Data type of the source image.
dstDataType  Data type of the destination image.
umChannels  Number of channels in the image. Possible values are 1, 3, or 4.
**pBufferSize**

Pointer to the size, in bytes, of the external buffer.

**Description**

This function computes the size, in bytes, of the external work buffer for the `ippiFilterHipassBorder` function. The result is stored in the `pBufferSize` parameter.

**Return Values**

- `ippStsNoErr`: Indicates no error. Any other value indicates an error.
- `ippStsNullPtrErr`: Indicates an error when `pBufferSize` is NULL.
- `ippStsSizeErr`: Indicates an error when `dstRoiSize` has a field with a zero or negative value.
- `ippStsMaskSizeErr`: Indicates an error when `mask` has an illegal value.
- `ippStsDataTypeErr`: Indicates an error when `srcDataType` or `dstDataType` has an illegal value.
- `ippStsNumChannelErr`: Indicates an error when `numChannels` has an illegal value.

**See Also**

- `FilterHipassBorder`: Filters an image using a high-pass filter.

**FilterHipassBorder**

*Filters an image using a high-pass filter.*

**Syntax**

**Case 1: Operating on one-channel data**

```c
IppStatus ippiFilterHipassBorder_8u_C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp8u borderValue, Ipp8u* pBuffer);
IppStatus ippiFilterHipassBorder_16s_C1R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp16s borderValue, Ipp8u* pBuffer);
IppStatus ippiFilterHipassBorder_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp32f borderValue, Ipp8u* pBuffer);
```

**Case 2: Operating on multi-channel data**

```c
IppStatus ippiFilterHipassBorder_8u_C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp8u pBorderValue[3], Ipp8u* pBuffer);
IppStatus ippiFilterHipassBorder_16s_C3R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp16s pBorderValue[3], Ipp8u* pBuffer);
IppStatus ippiFilterHipassBorder_32f_C3R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp32f pBorderValue[3], Ipp8u* pBuffer);
```
IppStatusippiFilterHipassBorder_8u_AC4R(constIpp8u*pSrc, int srcStep, Ipp8u*pDst, int dstStep, IppSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp8upBorderValue[3], Ipp8u*pBuffer);
IppStatusippiFilterHipassBorder_16s_AC4R(constIpp16spSrc, int srcStep, Ipp16spDst, int dstStep, IppSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp16spBorderValue[3], Ipp8u*pBuffer);
IppStatusippiFilterHipassBorder_32f_AC4R(constIpp32fpSrc, int srcStep, Ipp32fpDst, int dstStep, IppSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp32fpBorderValue[3], Ipp8u*pBuffer);
IppStatusippiFilterHipassBorder_8u_C4R(constIpp8u*pSrc, int srcStep, Ipp8u*pDst, int dstStep, IppSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp8upBorderValue[4], Ipp8u*pBuffer);
IppStatusippiFilterHipassBorder_16s_C4R(constIpp16spSrc, int srcStep, Ipp16spDst, int dstStep, IppSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp16spBorderValue[4], Ipp8u*pBuffer);
IppStatusippiFilterHipassBorder_32f_C4R(constIpp32fpSrc, int srcStep, Ipp32fpDst, int dstStep, IppSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp32fpBorderValue[4], Ipp8u*pBuffer);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pSrc  
srcStep  
pDst  
dstStep  
dstRoiSize  
mask  
borderType  

Pointer to the source image ROI.
Distance, in bytes, between the starting points of consecutive lines in the source image.
Pointer to the destination image ROI.
Distance, in bytes, between the starting points of consecutive lines in the destination image.
Size of the source and destination ROI, in pixels.
Predefined mask of IppiMaskSize. Possible values are ippMskSize3x3 or ippMskSize5x5.
Type of border. Possible values are:
ippBorderConst  
ippBorderRepl  
ippBorderInMem  
Values of all border pixels are set to constant.
Border is replicated from the edge pixels.
Border is obtained from the source image pixels in memory.
Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, or ippBorderMirror values and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.

\[ \text{borderValue} \]  
Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

\[ \text{pBorderValue}[3], \text{pBorderValue}[4] \]  
Pointer to constant values to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

\[ \text{pBuffer} \]  
Pointer to the work buffer.

**Description**

Before using this function, you need to compute the size of the work buffer \( \text{pBuffer} \) using the \text{ippiFilterHipassBorderGetBufferSize} function.

This function operates with ROI (see Regions of Interest in Intel IPP).

This function applies a high-pass filter to the \( \text{pSrc} \) source image ROI. The size of the source image ROI is equal to the destination image ROI size \( \text{dstRoiSize} \). The values of border pixels are assigned in accordance with the \( \text{borderType} \) and \( \text{borderValue} \) parameters. The kernel of the filter is a matrix of 3x3 or 5x5 size depending on the \( \text{mask} \) value. The kernels have the following values:

\[
\begin{array}{ccc}
-1 & -1 & -1 \\
-1 & 8 & -1 \\
-1 & -1 & -1 \\
\end{array}
\]  
\[
\begin{array}{cccc}
-1 & -1 & -1 & -1 \\
-1 & -1 & -1 & -1 \\
-1 & -1 & -1 & -1 \\
\end{array}
\]  
\[
\begin{array}{cc}
-1 & -1 \\
-1 & -1 \\
\end{array}
\]  

The anchor cell is the center cell of the kernel, highlighted in red.

**Return Values**

- ippStsNoErr  
  Indicates no error.

- ippStsNullPtrErr  
  Indicates an error when one of the specified pointers is NULL.

- ippStsSizeErr  
  Indicates an error when \( \text{dstRoiSize} \) is negative, or equal to zero.

- ippStsBorderErr  
  Indicates an error when \( \text{mask} \) has an illegal value.

- ippStsBorderErr  
  Indicates an error when \( \text{borderType} \) has an illegal value.

**See Also**

Borders in Neighborhood Operations  
Regions of Interest in Intel IPP  
User-defined Border Types  
FilterHipassBorderGetBufferSize  
Computes the size of the work buffer for high-pass filtering with the \text{ippiFilterHipassBorder} function.
FilterLaplaceBorderGetBufferSize
 Computes the size of the work buffer for Laplace filtering.

Syntax
IppStatus ippiFilterLaplaceBorderGetBufferSize(IppSize dstRoiSize, IppiMaskSize mask, IppDataType srcDataType, IppDataType dstDataType, int numChannels, int* pBufferSize);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

   dstRoiSize
   Size of the destination ROI, in pixels.

   mask
   Predefined mask of IppiMaskSize type. Possible values are:
   ippMskSize3x3 or ippMskSize5x5.

   srcDataType
   Data type of the source image.

   dstDataType
   Data type of the destination image.

   numChannels
   Number of channels in the image. Possible values are 1, 3, or 4.

   pBufferSize
   Pointer to the size, in bytes, of the external buffer.

Description
This function computes the size, in bytes, of the external work buffer for the ippiFilterLaplaceBorder function. The result is stored in the pBufferSize parameter.

Return Values

   ippStsNoErr
   Indicates no error. Any other value indicates an error.

   ippStsNullPtrErr
   Indicates an error when pBufferSize is NULL.

   ippStsSizeErr
   Indicates an error when dstRoiSize has a field with a zero or negative value.

   ippStsMaskSizeErr
   Indicates an error when mask has an illegal value.

   ippStsDataTypeErr
   Indicates an error when srcDataType or dstDataType has an illegal value.

   ippStsNumChannelErr
   Indicates an error when numChannels has an illegal value.

See Also
FilterLaplaceBorder Filters an image using a Laplace filter.
FilterLaplaceBorder
Filters an image using a Laplace filter.

Syntax
Case 1: Operating on one-channel data
IppStatus ippiFilterLaplaceBorder_8u_C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp8u borderValue, Ipp8u* pBuffer);
IppStatus ippiFilterLaplaceBorder_16s_C1R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp16s borderValue, Ipp8u* pBuffer);
IppStatus ippiFilterLaplaceBorder_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp32f borderValue, Ipp8u* pBuffer);

Case 2: Operating on multi-channel data
IppStatus ippiFilterLaplaceBorder_8u_C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp8u pBorderValue[3], Ipp8u* pBuffer);
IppStatus ippiFilterLaplaceBorder_16s_C3R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp16s pBorderValue[3], Ipp8u* pBuffer);
IppStatus ippiFilterLaplaceBorder_32f_C3R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp32f pBorderValue[3], Ipp8u* pBuffer);
IppStatus ippiFilterLaplaceBorder_8u_AC4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp8u pBorderValue[4], Ipp8u* pBuffer);
IppStatus ippiFilterLaplaceBorder_16s_AC4R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp16s pBorderValue[4], Ipp8u* pBuffer);
IppStatus ippiFilterLaplaceBorder_32f_AC4R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp32f pBorderValue[4], Ipp8u* pBuffer);

Include Files
ippi.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc
srcStep
pDst
dstStep
dstRoiSize
mask
borderType

Pointer to the source image ROI.
Distance, in bytes, between the starting points of consecutive lines in the source image.
Pointer to the destination image ROI.
Distance, in bytes, between the starting points of consecutive lines in the destination image.
Size of the source and destination ROI, in pixels.
Predefined mask of IppiMaskSize. Possible values are ippMskSize3x3 or ippMskSize5x5.
Type of border. Possible values are:
ippBorderConst  Values of all border pixels are set to constant.
ippBorderRepl  Border is replicated from the edge pixels.
ippBorderInMem  Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, or ippBorderMirror values and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.

borderValue

Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

pBorderValue[3], pBorderValue[4]

Pointer to constant values to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

pBuffer

Description

Before using this function, you need to compute the size of the work buffer pBuffer using the ippiFilterLaplaceBorderGetBufferSize function.

This function operates with ROI (see Regions of Interest in Intel IPP).
This function applies a Laplace filter to the \texttt{pSrc} source image ROI. The size of the source image ROI is equal to the destination image ROI size \texttt{dstRoiSize}. The values of border pixels are assigned in accordance with the \texttt{borderType} and \texttt{borderValue} parameters. The kernel of the filter is a matrix of 3x3 or 5x5 size depending on the \texttt{mask} value. The kernels have the following values:

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>-3</td>
<td>-4</td>
<td>-3</td>
<td>-1</td>
</tr>
<tr>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-3</td>
<td>0</td>
</tr>
<tr>
<td>-1</td>
<td>8</td>
<td>-1</td>
<td>-4</td>
<td>6</td>
</tr>
<tr>
<td>-1</td>
<td>-1</td>
<td>-1</td>
<td>-3</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>-1</td>
<td>-3</td>
<td>-4</td>
<td>-3</td>
</tr>
</tbody>
</table>

The anchor cell is the center cell of the kernel, highlighted in red.

**Return Values**

- \texttt{ippStsNoErr} Indicates no error.
- \texttt{ippStsNullPtrErr} Indicates an error when one of the specified pointers is \texttt{NULL}.
- \texttt{ippStsSizeErr} Indicates an error when \texttt{dstRoiSize} is negative, or equal to zero.
- \texttt{ippStsBorderErr} Indicates an error when \texttt{mask} has an illegal value.
- \texttt{ippStsBorderErr} Indicates an error when \texttt{borderType} has an illegal value.

**See Also**

Borders in Neighborhood Operations
Regions of Interest in Intel IPP
User-defined Border Types
FilterLaplaceBorder Filters an image using a Laplace filter.

**FilterLaplacianGetBufferSize**

*Computes the size of the external buffer for the Laplace filter with border.*

**Syntax**

\[
\text{IppStatus ippiFilterLaplacianGetBufferSize}_{<\text{mod}>}(\text{IppSize roiSize}, \text{IppiMaskSize mask}, \text{int* } pBufferSize);
\]

**Supported values for** \texttt{mod}:

- \texttt{8u16s_C1R}
- \texttt{32f_C1R}

**Include Files**

\texttt{ippcv.h}

**Domain Dependencies**

**Headers:** \texttt{ippcore.h, ippvm.h, ipps.h,ippi.h}

**Libraries:** \texttt{ippcore.lib, ippvm.lib, ipps.lib,ippi.lib}
Parameters

roiSize
Maximum size of the source and destination image ROI.

mask
Predefined mask of IppiMaskSize type.

pBufferSize
Pointer to the buffer size.

Description
This function computes the size of the external buffer that is required for the filter function
ippiFilterLaplacianBorder. The kernel of the filter is the matrix of either 3x3 or 5x5 size that is
specified by the parameter mask (see Table “Types of the Fixed Filter Functions”). This buffer
pBufferSize[0] can be used to filter an image whose width and height are equal to or less than
the corresponding fields of roiSize.

Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error or a
warning.

ippStsNullPtrErr
Indicates an error condition if the pBufferSize pointer is NULL.

ippStsSizeErr
Indicates an error condition if roiSize has a field with a zero or
negative value.

ippStsMaskSizeErr
Indicates an error condition if mask has a wrong value.

FilterLaplacianBorder
Applies Laplacian filter with border.

Syntax
IppStatus ippiFilterLaplacianBorder_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep,
Ipp<dstDatatype>* pDst, int dstStep, IppiSize roiSize, IppiMaskSize mask,
IppiBorderType borderType, Ipp<srcDatatype> borderValue, Ipp8u* pBuffer);

Supported values for mod:
8u16s_C1R 32f_C1R

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc
Pointer to the source image ROI.

srcStep
Distance in bytes between starts of consecutive lines in the source image.

pDst
Pointer to the destination image ROI.
**dstStep**

Distance in bytes between starts of consecutive lines in the destination image.

**roiSize**

Size of the source and destination image ROI.

**mask**

Type of the filter kernel.

**borderType**

Type of border (see Borders in Neighborhood Operations); following values are possible:

- `ippBorderConst`: Values of all border pixels are set to constant.
- `ippBorderRep`: Replicated border is used.
- `ippBorderMirror`: Border pixels are mirrored from the source image boundary pixels.

**borderValue**

The constant value to assign to the pixels in the constant border (not applicable for other border's type).

**pBuffer**

Pointer to the working buffer.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function applies the laplacian filter to the source image `pSrc` and stores results to the destination image of the same size `pDst`. Source image can be used as the destination image if they both have the same data type. The values of border pixels are assigned in accordance with the `borderType` and `borderValue` parameters. The kernel of this filter is the matrix of either 3x3 or 5x5 size that is specified by the parameter `mask`. The kernels have the following values with the anchor in the center cell (red):

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>4</th>
<th>4</th>
<th>4</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>-8</td>
<td>0</td>
<td>or</td>
<td>-8</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>2</td>
<td></td>
<td>-8</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

The function requires the working buffer `pBuffer` whose size should be computed by the function `ippiFilterLaplacianGetBufferSize` beforehand.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if `roiSize` has a field with a zero or negative value.
- **ippStsStepErr**: Indicates an error condition if `srcStep` or `dstStep` is less than `roiSize.width * <pixelSize>`.
- **ippStsNotEvenStepErr**: Indicates an error condition if one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.
ippStsBadArgErr  Indicates an error if borderType or divisor has a wrong value.
ippStsMaskErr  Indicates an error condition if mask has a wrong value.

**FilterLowpassGetBufferSize**

*Computes the size of the external buffer for the lowpass filter with border.*

**Syntax**

IppStatus ippiFilterLowpassGetBufferSize_8u_C1R(IppSize roiSize, IppiMaskSize mask, int* pBufferSize);
IppStatus ippiFilterLowpassGetBufferSize_32f_C1R(IppSize roiSize, IppiMaskSize mask, int* pBufferSize);

**Include Files**

ippcv.h

**Domain Dependencies**

*Headers:* ippcore.h, ippvm.h, ipps.h,ippi.h

*Libraries:* ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- roiSize  Maximum size of the source and destination image ROI.
- mask  Predefined mask of IppiMaskSize type.
- pBufferSize  Pointer to the buffer size.

**Description**

This function computes the size of the external buffer that is required for the filter function ippiFilterLowpassBorder. The kernel of the filter is the matrix of either 3x3 or 5x5 size that is specified by the parameter mask (see Table "Types of the Fixed Filter Functions"). This buffer pBufferSize[0] can be used to filter an image whose width and height are equal to or less than corresponding fields of roiSize.

**Return Values**

- ippStsNoErr  Indicates no error. Any other value indicates an error or a warning.
- ippStsNullFptrErr  Indicates an error condition if the pBufferSize pointer is NULL.
- ippStsSizeErr  Indicates an error condition if roiSize has a field with a zero or negative value.
- ippStsMaskSizeErr  Indicates an error condition if mask has a wrong value.

**FilterLowpassBorder**

*Applies lowpass filter with border.*
Syntax

IppStatus ippiFilterLowpassBorder_8u_C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppSize roiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp8u borderValue, Ipp8u* pBuffer);

IppStatus ippiFilterLowpassBorder_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp32f borderValue, Ipp8u* pBuffer);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters

pSrc  
Pointer to the source image ROI.

srcStep  
Distance in bytes between starts of consecutive lines in the source image.

pDst  
Pointer to the destination image ROI.

dstStep  
Distance in bytes between starts of consecutive lines in the destination image.

roiSize  
Size of the source and destination image ROI.

mask  
Type of the filter kernel.

borderType  
Type of border (see Borders in Neighborhood Operations); the following values are possible:

ippBorderConst  
Values of all border pixels are set to constant.

ippBorderRepl  
Replicated border is used.

borderValue  
The constant value to assign to the pixels in the constant border (not applicable for other border's type).

pBuffer  
Pointer to the working buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function applies the lowpass filter (blur operation) to the source image pSrc and stores results to the destination image of the same size pDst. Source image can be used as the destination image if they both have the same data type. The values of border pixels are assigned in accordance with the borderType and borderValue parameters. The kernel of this filter is the matrix of either 3x3 or 5x5 size that is specified by the parameter mask. The anchor cell is the center cell (red) of the kernel.
The 3x3 filter uses the kernel with the following values:

\[
\begin{bmatrix}
1/9 & 1/9 & 1/9 \\
1/9 & 1/9 & 1/9 \\
1/9 & 1/9 & 1/9 \\
\end{bmatrix}
\]

The 5x5 filter uses the kernel with the following values:

\[
\begin{bmatrix}
1/25 & 1/25 & 1/25 & 1/25 & 1/25 \\
1/25 & 1/25 & 1/25 & 1/25 & 1/25 \\
1/25 & 1/25 & 1/25 & 1/25 & 1/25 \\
1/25 & 1/25 & 1/25 & 1/25 & 1/25 \\
1/25 & 1/25 & 1/25 & 1/25 & 1/25 \\
\end{bmatrix}
\]

The function requires the working buffer `pBuffer` whose size should be computed by the function `ippiFilterLowpassGetBufferSize` beforehand.

**Return Values**

- `ippStsNoErr`: Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr`: Indicates an error condition if one of the specified pointers is NULL.
- `ippStsSizeErr`: Indicates an error condition if `roiSize` has a field with a zero or negative value.
- `ippStsStepErr`: Indicates an error condition if `srcStep` or `dstStep` is less than `roiSize.width * pixelSize`.
- `ippStsNotEvenStepErr`: Indicates an error condition if one of the step values is not divisible by 4 for floating-point images.
- `ippStsBorderErr`: Indicates an error condition if `borderType` has a wrong value.
- `ippStsMaskErr`: Indicates an error condition if `mask` has a wrong value.

**FilterPrewittHorizBorderGetBufferSize**

*Computes the size of the work buffer for the Prewitt Horizontal filter.*

**Syntax**

```c
IppStatus ippiFilterPrewittHorizBorderGetBufferSize (IppiSize dstRoiSize, IppiMaskSize mask, IppDataType srcDataType, IppDataType dstDataType, int numChannels, int* pBufferSize);
```

**Include Files**

`ippi.h`

**Parameters**

- `dstRoiSize`: Size of the destination ROI in pixels.
mask

Predefined mask of IppiMaskSize type. Possible value is ippMskSize3x3.

srcDataType

Data type of the source image.

dstDataType

Data type of the destination image.

numChannels

Number of channels in the image. Possible value is 1.

pBufferSize

Pointer to the size of the external work buffer.

Description

The ippiFilterPrewittHorizBorderGetBufferSize function computes the size, in bytes, of the external work buffer needed for the ippiFilterPrewittHorizBorder function. The result is stored in the pBufferSize parameter.

For an example on how to use this function, see the code example provided with the ippiFilterPrewittHorizBorder function description.

Return Values

ippStsNoErr  Indicates no error.

ippStsNullPtrErr  Indicates an error when pBufferSize is NULL.

ippStsSizeErr  Indicates an error when dstRoiSize is negative, or equal to zero.

ippStsMaskSizeErr  Indicates an error when mask has an illegal value.

ippStsDataTypeErr  Indicates an error when srcDataType or dstDataType has an illegal value.

ippStsNumChannelsError  Indicates an error when numChannels has an illegal value.

See Also

FilterPrewittHorizBorder  Filters and image using a horizontal Prewitt filter.

FilterPrewittHorizBorder

Filters and image using a horizontal Prewitt filter.

Syntax

IppStatus ippiFilterPrewittHorizBorder_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp<srcDatatype> borderValue, Ipp8u* pBuffer);

Supported values for mod:

8u16s_C1R 16s_C1R 32f_C1R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance, in bytes, between the starting points of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance, in bytes, between the starting points of consecutive lines in the destination image.
- **dstRoiSize**: Size of the source and destination ROI in pixels.
- **mask**: Predefined mask of IppiMaskSize. Possible value is ippMskSize3x3.
- **borderType**: Type of border. Possible values are:
  - ippBorderConst: Values of all border pixels are set to constant.
  - ippBorderRepl: Border is replicated from the edge pixels.
  - ippBorderMirror: Mirrored border is used.
  - ippBorderMirrorR: Mirrored border with replication is used.
  - ippBorderInMem: Border is obtained from the source image pixels in memory.
  
  Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, ippBorderMirror, or ippBorderMirrorR values, and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.
- **borderValue**: Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.
- **pBuffer**: Pointer to the work buffer.

Description

Before using this function, you need to compute the size of the work buffer *pBuffer* using the FilterPrewittHorizBorderGetBufferSize function.

This function operates with ROI.
This function applies a horizontal Prewitt filter to the \textit{pSrc} source image ROI. The size of the source image ROI is equal to the destination image ROI size \textit{dstRoiSize}. The values of border pixels are assigned in accordance with the \textit{borderType} and \textit{borderValue} parameters. The kernel of the filter is a matrix of 3x3 size with the following values:

\begin{tabular}{ccc}
  1 & 1 & 1 \\
  0 & 0 & 0 \\
  -1 & -1 & -1 \\
\end{tabular}

The anchor cell is the center cell of the kernel, highlighted in red.

This filter enhances horizontal edges of an image.

**Return Values**

- \textbf{ippStsNoErr} Indicates no error.
- \textbf{ippStsNullPtrErr} Indicates an error when one of the specified pointers is \texttt{NULL}.
- \textbf{ippStsSizeErr} Indicates an error when \textit{dstRoiSize} is negative, or equal to zero.
- \textbf{ippStsStepErr} Indicates an error when \textit{srcStep} or \textit{dstStep} is negative, or equal to zero.
- \textbf{ippStsNotEvenStepErr} Indicates an error when one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.
- \textbf{ippStsBorderErr} Indicates an error when \textit{borderType} has an illegal value.

**Example**

To better understand usage of this function, refer to the FilterConvolutionKernels.c and FilterPrewittHorizBorder.c examples in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

**See Also**

Borders in Neighborhood Operations
Regions of Interest in Intel IPP
User-defined Border Types
FilterPrewittHorizBorderGetBufferSize Computes the size of the work buffer for the Prewitt Horizontal filter.

**FilterPrewittVertBorderGetBufferSize**

\textit{Computes the size of the work buffer for the Prewitt Vertical filter.}

**Syntax**

\texttt{IppStatus ippiFilterPrewittVertBorderGetBufferSize (IppiSize dstRoiSize, IppiMaskSize mask, IppDataType srcDataType, IppDataType dstDataType, int numChannels, int* pBufferSize);}
Parameters

- **dstRoiSize**: Size of the destination ROI in pixels.
- **mask**: Predefined mask of IppiMaskSize type. Possible value is ippMskSize3x3.
- **srcDataType**: Data type of the source image.
- **dstDataType**: Data type of the destination image.
- **numChannels**: Number of channels in the image. Possible value is 1.
- **pBufferSize**: Pointer to the size of the external work buffer.

Description

The `ippiFilterPrewittVertBorderGetBufferSize` function computes the size, in bytes, of the external work buffer needed for the `ippiFilterPrewittVertBorder` function. The result is stored in the `pBufferSize` parameter.

For an example on how to use this function, see the code example provided with the `ippiFilterPrewittVertBorder` function description.

Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error when `pBufferSize` is NULL.
- **ippStsSizeErr**: Indicates an error when `dstRoiSize` is negative, or equal to zero.
- **ippStsMaskSizeErr**: Indicates an error when `mask` has an illegal value.
- **ippStsDataTypeErr**: Indicates an error when `srcDataType` or `dstDataType` has an illegal value.
- **ippStsNumChannelsError**: Indicates an error when `numChannels` has an illegal value.

See Also

- **FilterPrewittVertBorder**: Filters and image using a vertical Prewitt kernel.
- **FilterPrewittVertBorder**: Filters and image using a vertical Prewitt kernel.

Syntax

```c
IppStatus ippiFilterPrewittVertBorder_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp<srcDatatype> borderValue, Ipp8u* pBuffer);
```

Supported values for `mod`:

- 8u16s_C1R
- 16s_C1R
- 32f_C1R

Include Files

ippi.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance, in bytes, between the starting points of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance, in bytes, between the starting points of consecutive lines in the destination image.
- **dstRoiSize**: Size of the source and destination ROI in pixels.
- **mask**: Predefined mask of IppiMaskSize. Possible value is ippMskSize3x3.
- **borderType**: Type of border. Possible values are:
  - ippBorderConst: Values of all border pixels are set to constant.
  - ippBorderRepl: Border is replicated from the edge pixels.
  - ippBorderMirror: Mirrored border is used.
  - ippBorderMirrorR: Mirrored border with replication is used.
  - ippBorderInMem: Border is obtained from the source image pixels in memory.
  - Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, ippBorderMirror, or ippBorderMirrorR values and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.
- **borderValue**: Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.
- **pBuffer**: Pointer to the work buffer.

Description

Before using this function, you need to compute the size of the work buffer pBuffer using the FilterPrewittVertBorderGetBufferSize function.

This function operates with ROI.
This function applies a vertical Prewitt filter to the `pSrc` source image ROI. The size of the source image ROI is equal to the destination image ROI size `dstRoiSize`. The values of border pixels are assigned in accordance with the `borderType` and `borderValue` parameters. The kernel of the filter is a matrix of 3x3 size with the following values:

<table>
<thead>
<tr>
<th>-1</th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>-1</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

The anchor cell is the center cell of the kernel, highlighted in red.

This filter enhances vertical edges of an image.

### Return Values

- `ippStsNoErr`  
  Indicates no error.

- `ippStsNullPtrErr`  
  Indicates an error when one of the specified pointers is `NULL`.

- `ippStsSizeErr`  
  Indicates an error when `dstRoiSize` is negative, or equal to zero.

- `ippStsStepErr`  
  Indicates an error when `srcStep` or `dstStep` is negative, or equal to zero.

- `ippStsNotEvenStepErr`  
  Indicates an error when one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.

- `ippStsBorderErr`  
  Indicates an error when `borderType` has an illegal value.

### Example

To better understand usage of this function, refer to the `FilteringConvolutionKernels.c` example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

### See Also

- Borders in Neighborhood Operations
- Regions of Interest in Intel IPP
- User-defined Border Types
- `FilterPrewittVertBorderGetBufferSize`  
  Computes the size of the work buffer for the Prewitt Vertical filter.

### FilterRobertsUpBorderGetBufferSize

*Computes the size of the work buffer for the vertical Roberts edge filter.*

#### Syntax

```c
IppStatus ippiFilterRobertsUpBorderGetBufferSize (IppSize dstRoiSize, IppiMaskSize mask, IppDataType srcDataType, IppDataType dstDataType, int numChannels, int* pBufferSize);
```

#### Include Files

`ippi.h`
Parameters

- **dstRoiSize**: Size of the destination ROI in pixels.
- **mask**: Predefined mask of IppiMaskSize type. Possible value is ippMskSize3x3.
- **srcDataType**: Data type of the source image.
- **dstDataType**: Data type of the destination image.
- **numChannels**: Number of channels in the image. Possible value is 1.
- **pBufferSize**: Pointer to the size of the external work buffer.

Description

The `ippiFilterRobertsUpBorderGetBufferSize` function computes the size, in bytes, of the external work buffer needed for the `ippiFilterRobertsUpBorder` function. The result is stored in the `pBufferSize` parameter.

For an example on how to use this function, see the code example provided with the `ippiFilterRobertsUpBorder` function description.

Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error when `pBufferSize` is NULL.
- **ippStsSizeErr**: Indicates an error when `dstRoiSize` is negative, or equal to zero.
- **ippStsMaskSizeErr**: Indicates an error when `mask` has an illegal value.
- **ippStsDataTypeErr**: Indicates an error when `srcDataType` or `dstDataType` has an illegal value.
- **ippStsNumChannelsError**: Indicates an error when `numChannels` has an illegal value.

See Also

- **FilterRobertsUpBorder** Filters an image using a vertical Roberts edge filter.

**FilterRobertsUpBorder**
Filters an image using a vertical Roberts edge filter.

Syntax

```c
IppStatus ippiFilterRobertsUpBorder_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp<srcDatatype> borderValue, Ipp8u* pBuffer);
```

Supported values for `mod`:

- 8u16s_C1R
- 16s_C1R
- 32f_C1R

Include Files

ippi.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starting points of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starting points of consecutive lines in the destination image.
- **dstRoiSize**: Size of the source and destination ROI in pixels.
- **mask**: Predefined mask of IppiMaskSize. Possible value is ippMskSize3x3.
- **borderType**: Type of border. Possible values are:
  - ippBorderConst: Values of all border pixels are set to constant.
  - ippBorderRepl: Border is replicated from the edge pixels.
  - ippBorderMirror: Mirrored border is used.
  - ippBorderMirrorR: Mirrored border with replication is used.
  - ippBorderInMem: Border is obtained from the source image pixels in memory.
  Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, ippBorderMirror, or ippBorderMirrorR values and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.
- **borderValue**: Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.
- **pBuffer**: Pointer to the work buffer.

Description

This function operates with ROI.
This function applies a vertical Roberts edge filter to the \textit{pSrc} source image ROI. The size of the source image ROI is equal to the destination image ROI size \textit{dstRoiSize}. The values of border pixels are assigned in accordance with the \textit{borderType} and \textit{borderValue} parameters. The kernel of the filter is a matrix of 3x3 size with the following values:

\begin{verbatim}
| 0  0  0 |
| 0  1  0 |
| -1 0  0 |
\end{verbatim}

The anchor cell is the center cell of the kernel, highlighted in red.

This filter provides the gross approximation of the pixel values gradient in the vertical direction.

Before using this function, you need to compute the size of the work buffer \textit{pBuffer} using the \texttt{FilterRobertsUpBorderGetBufferSize} function.

**Return Values**

- \texttt{ippStsNoErr} Indicates no error.
- \texttt{ippStsNullPtrErr} Indicates an error when one of the specified pointers is \texttt{NULL}.
- \texttt{ippStsSizeErr} Indicates an error when \textit{dstRoiSize} is negative, or equal to zero.
- \texttt{ippStsStepErr} Indicates an error when \textit{srcStep} or \textit{dstStep} is negative, or equal to zero.
- \texttt{ippStsNotEvenStepErr} Indicates an error when one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.
- \texttt{ippStsBorderErr} Indicates an error when \textit{borderType} has an illegal value.

**Example**

To better understand usage of this function, refer to the \texttt{FilteringConvolutionKernels.c} example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

**See Also**

Borders in Neighborhood Operations
Regions of Interest in Intel IPP
User-defined Border Types
\texttt{FilterRobertsUpBorderGetBufferSize} Computed the size of the work buffer for the vertical Roberts edge filter.

**FilterRobertsDownBorderGetBufferSize**

\textit{Computes the size of the work buffer for the horizontal Roberts edge filter.}

**Syntax**

\begin{verbatim}
IppStatus ippiFilterRobertsDownBorderGetBufferSize (IppSize dstRoiSize, IppiMaskSize mask, IppDataType srcDataType, IppDataType dstDataType, int numChannels, int* pBufferSize);
\end{verbatim}

**Include Files**

\texttt{ippi.h}
Parameters

dstRoiSize
Size of the destination ROI in pixels.

mask
Predefined mask of IppiMaskSize type. Possible value is ippMskSize3x3.

srcDataType
Data type of the source image.

dstDataType
Data type of the destination image.

numChannels
Number of channels in the image. Possible value is 1.

pBufferSize
Pointer to the size of the external work buffer.

Description
The ippiFilterRobertsDownBorderGetBufferSize function computes the size, in bytes, of the external work buffer needed for the ippiFilterRobertsDownBorder function. The result is stored in the pBufferSize parameter.

For an example on how to use this function, see the code example provided with the ippiFilterRobertsDownBorder function description.

Return Values

ippStsNoErr
Indicates no error.

ippStsNullPtrErr
Indicates an error when pBufferSize is NULL.

ippStsSizeErr
Indicates an error when dstRoiSize is negative, or equal to zero.

ippStsMaskSizeErr
Indicates an error when mask has an illegal value.

ippStsDataTypeErr
Indicates an error when srcDataType or dstDataType has an illegal value.

ippStsNumChannelsError
Indicates an error when numChannels has an illegal value.

FilterRobertsDownBorder
Filters an image using a horizontal Roberts edge filter.

FilterRobertsDownBorder
Filters an image using a horizontal Roberts edge filter.

Syntax

IppStatus ippiFilterRobertsDownBorder_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp<srcDatatype> borderValue, Ipp8u* pBuffer);

Supported values for mod:
8u16s_C1R 16s_C1R 32f_C1R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance, in bytes, between the starting points of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance, in bytes, between the starting points of consecutive lines in the destination image.
- **dstRoiSize**: Size of the source and destination ROI in pixels.
- **mask**: Predefined mask of IppiMaskSize. Possible value is ippMskSize3x3.
- **borderType**: Type of border. Possible values are:
  - ippBorderConst: Values of all border pixels are set to constant.
  - ippBorderRepl: Border is replicated from the edge pixels.
  - ippBorderMirror: Mirrored border is used.
  - ippBorderMirrorR: Mirrored border with replication is used.
  - ippBorderInMem: Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, ippBorderMirror, or ippBorderMirrorR values, and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.

- **borderValue**: Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.
- **pBuffer**: Pointer to the work buffer.

Description

Before using this function, you need to compute the size of the work buffer pBuffer using the FilterRobertsDownBorderGetBufferSize function.

This function operates with ROI.
This function applies a horizontal Roberts edge filter to the `pSrc` source image ROI. The size of the source image ROI is equal to the destination image ROI size `dstRoiSize`. The values of border pixels are assigned in accordance with the `borderType` and `borderValue` parameters. The kernel of the filter is a matrix of 3x3 size with the following values:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>-1</td>
</tr>
</tbody>
</table>

The anchor cell is the center cell of the kernel, highlighted in red.

This filter provides the gross approximation of the pixel values gradient in the horizontal direction.

### Return Values

- **ippStsNoErr**
  - Indicates no error.
- **ippStsNullPtrErr**
  - Indicates an error when one of the specified pointers is `NULL`.
- **ippStsSizeErr**
  - Indicates an error when `dstRoiSize` is negative, or equal to zero.
- **ippStsStepErr**
  - Indicates an error when `srcStep` or `dstStep` is negative, or equal to zero.
- **ippStsNotEvenStepErr**
  - Indicates an error when one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.
- **ippStsBorderErr**
  - Indicates an error when `borderType` has an illegal value.

### Example

To better understand usage of this function, refer to the `FilteringConvolutionKernels.c` example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

### See Also

- Borders in Neighborhood Operations
- Regions of Interest in Intel IPP
- User-defined Border Types
- `FilterRobertsDownBorderGetBufferSize` Computes the size of the work buffer for the horizontal Roberts edge filter.

### FilterScharrHorizMaskBorderGetBufferSize

*Computes the size of the work buffer for the Scharr Horizontal filter.*

#### Syntax

```
IppStatus ippiFilterScharrHorizMaskBorderGetBufferSize (IppiSize dstRoiSize,
IppiMaskSize mask, IppDataType srcDataType, IppDataType dstDataType, int numChannels,
int* pBufferSize);
```

#### Include Files

`ippi.h`
Parameters

dstRoiSize
Size of the destination ROI in pixels.

mask
Predefined mask of IppiMaskSize type. Possible value is ippMskSize3x3.

srcDataType
Data type of the source image.

dstDataType
Data type of the destination image.

numChannels
Number of channels in the image. Possible value is 1.

pBufferSize
Pointer to the size of the external work buffer.

Description

The ippiFilterScharrHorizMaskBorderGetBufferSize function computes the size, in bytes, of the external work buffer needed for the ippiFilterScharrHorizMaskBorder function. The result is stored in the pBufferSize parameter.

For an example on how to use this function, see the code example provided with the ippiFilterScharrHorizMaskBorder function description.

Return Values

ippiStsNoErr
Indicates no error.

ippiStsNullPtrErr
Indicates an error when pBufferSize is NULL.

ippiStsSizeErr
Indicates an error when dstRoiSize is negative, or equal to zero.

ippiStsMaskSizeErr
Indicates an error when mask has an illegal value.

ippiStsDataTypeErr
Indicates an error when srcDataType or dstDataType has an illegal value.

ippiStsNumChannelsError
Indicates an error when numChannels has an illegal value.

See Also

FilterScharrHorizMaskBorder  Filters an image using a horizontal Scharr filter.

FilterScharrHorizMaskBorder
Filters an image using a horizontal Scharr filter.

Syntax

IppStatus ippiFilterScharrHorizMaskBorder_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp<srcDatatype> borderValue, Ipp8u* pBuffer);

Supported values for mod:

8u16s_C1R  16s_C1R  32f_C1R

Include Files

ippi.h
Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance, in bytes, between the starting points of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance, in bytes, between the starting points of consecutive lines in the destination image.
- **dstRoiSize**: Size of the source and destination ROI in pixels.
- **mask**: Predefined mask of IppiMaskSize. Possible value is ippMskSize3x3.
- **borderType**: Type of border. Possible values are:
  - ippBorderConst: Values of all border pixels are set to constant.
  - ippBorderRepl: Border is replicated from the edge pixels.
  - ippBorderMirror: Mirrored border is used.
  - ippBorderMirrorR: Mirrored border with replication is used.
  - ippBorderInMem: Border is obtained from the source image pixels in memory.
  - ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight: Values.
- **borderValue**: Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.
- **pBuffer**: Pointer to the work buffer.

Description
Before using this function, you need to compute the size of the work buffer **pBuffer** using the FilterScharrHorizMaskBorderGetBufferSize function.

This function operates with ROI.
This function applies a horizontal Scharr filter to the pSrc source image ROI. The size of the source image ROI is equal to the destination image ROI size dstRoiSize. The values of border pixels are assigned in accordance with the borderType and borderValue parameters. The kernel of the filter is a matrix of 3x3 size with the following values:

<table>
<thead>
<tr>
<th></th>
<th>3</th>
<th>10</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>-10</td>
<td>-3</td>
<td></td>
</tr>
</tbody>
</table>

The anchor cell is the center cell of the kernel, highlighted in red.

This filter enhances horizontal edges of an image.

## Return Values

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error when one of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error when dstRoiSize is negative, or equal to zero.</td>
</tr>
<tr>
<td>ippStsStepErr</td>
<td>Indicates an error when srcStep or dstStep is negative, or equal to zero.</td>
</tr>
<tr>
<td>ippStsNotEvenStepErr</td>
<td>Indicates an error when one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.</td>
</tr>
<tr>
<td>ippStsBorderErr</td>
<td>Indicates an error when borderType has an illegal value.</td>
</tr>
</tbody>
</table>

## Example

To better understand usage of this function, refer to the `FilteringConvolutionKernels.c` example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

## See Also

- Borders in Neighborhood Operations
- Regions of Interest in Intel IPP
- User-defined Border Types
- FilterPrewittHorizBorderGetBufferSize Computes the size of the work buffer for the Prewitt Horizontal filter.

## FilterScharrVertMaskBorderGetBufferSize

### Computes the size of the work buffer for the Scharr Vertical filter.

### Syntax

```c
IppStatus ippiFilterScharrVertMaskBorderGetBufferSize (IppSize dstRoiSize, IppiMaskSize mask, IppDataType srcDataType, IppDataType dstDataType, int numChannels, int* pBufferSize);
```

### Include Files

`ippi.h`
Parameters

- **dstRoiSize**: Size of the destination ROI in pixels.
- **mask**: Predefined mask of `IppiMaskSize` type. Possible value is `ippMskSize3x3`.
- **srcDataType**: Data type of the source image.
- **dstDataType**: Data type of the destination image.
- **numChannels**: Number of channels in the image. Possible value is 1.
- **pBufferSize**: Pointer to the size of the external work buffer.

Description

The `ippiFilterScharrVertMaskBorderGetBufferSize` function computes the size, in bytes, of the external work buffer needed for the `ippiFilterScharrVertMaskBorder` function. The result is stored in the `pBufferSize` parameter.

For an example on how to use this function, see the code example provided with the `ippiFilterScharrVertMaskBorder` function description.

Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error when `pBufferSize` is NULL.
- **ippStsSizeErr**: Indicates an error when `dstRoiSize` is negative, or equal to zero.
- **ippStsMaskSizeErr**: Indicates an error when `mask` has an illegal value.
- **ippStsDataTypeErr**: Indicates an error when `srcDataType` or `dstDataType` has an illegal value.
- **ippStsNumChannelsError**: Indicates an error when `numChannels` has an illegal value.

See Also

- **FilterScharrVertMaskBorder**: Filters an image using a vertical Scharr kernel.

**FilterScharrVertMaskBorder**

*Filters an image using a vertical Scharr kernel.*

Syntax

```c
IppStatus ippiFilterScharrVertMaskBorder_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp<srcDatatype> borderValue, Ipp8u* pBuffer);
```

Supported values for `mod`:

- `8u16s_C1R`  
- `16s_C1R`  
- `32f_C1R`

Include Files

- `ippi.h`
Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

*pSrc*  
Pointer to the source image ROI.

*srcStep*  
Distance, in bytes, between starting points of consecutive lines in the source image.

*pDst*  
Pointer to the destination image ROI.

*dstStep*  
Distance, in bytes, between starting points of consecutive lines in the destination image.

*dstRoiSize*  
Size of the source and destination ROI in pixels.

*mask*  
Predefined mask of IppiMaskSize. Possible value is ippMskSize3x3.

*borderType*  
Type of border. Possible values are:

- ippBorderConst  
Values of all border pixels are set to constant.

- ippBorderRepl  
Border is replicated from the edge pixels.

- ippBorderMirror  
Mirrored border is used.

- ippBorderMirrorR  
Mirrored border with replication is used.

- ippBorderInMem  
Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, ippBorderMirror, or ippBorderMirrorR values and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.

*borderValue*  
Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

*pBuffer*  
Pointer to the work buffer.

Description
This function operates with ROI.
This function applies a vertical Scharr filter to the *pSrc* source image ROI. The size of the source image ROI is equal to the destination image ROI size *dstRoiSize*. The values of border pixels are assigned in accordance with the *borderType* and *borderValue* parameters. The kernel of the filter is a matrix of 3x3 size with the following values:

<table>
<thead>
<tr>
<th></th>
<th>-3</th>
<th>0</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10</td>
<td>0</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>-3</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

The anchor cell is the center cell of the kernel, highlighted in red.

This filter enhances horizontal edges of an image.

Before using this function, you need to compute the size of the work buffer *pBuffer* using the `ippiFilterScharrVertMaskBorderGetBufferSize` function.

**Return Values**

- **ippStsNoErr**
  Indicates no error.

- **ippStsNullPtrErr**
  Indicates an error when one of the specified pointers is NULL.

- **ippStsSizeErr**
  Indicates an error when *dstRoiSize* is negative, or equal to zero.

- **ippStsStepErr**
  Indicates an error when *srcStep* or *dstStep* is negative, or equal to zero.

- **ippStsNotEvenStepErr**
  Indicates an error when one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.

- **ippStsBorderErr**
  Indicates an error when *borderType* has an illegal value.

**Example**

The code example below demonstrates how to use the `ippiFilterScharrVertMaskBorderGetBufferSize` and `ippiFilterScharrVertMaskBorder_8u16s_C1R` functions.

```c
IppStatus fix_scharrvert_8u16( void ) {
    Ipp8u pSrc[9*8] = {
        0, 1, 2, 120, 121, 122, 50, 51, 52,
        1, 2, 3, 121, 122, 123, 52, 52, 53,
        3, 4, 5, 130, 131, 132, 63, 64, 65,
        4, 5, 6, 131, 132, 133, 64, 65, 66,
        5, 6, 7, 132, 133, 134, 65, 66, 67,
        8, 7, 6, 134, 133, 132, 67, 66, 65,
        7, 6, 5, 133, 132, 131, 66, 65, 64,
        6, 5, 4, 132, 131, 130, 65, 64, 63
    };
    Ipp16s pDst[8*7];
    Ipp8u *pBuffer;
    IppiSize roiSize = {8, 7};
    IppiBorderType borderType = ippBorderRepl | ippBorderInMemTop | ippBorderInMemRight;
    int srcStep = 9 * sizeof(Ipp8u);
    int dstStep = 8 * sizeof(Ipp16s);
    int bufferSize;
    IppStatus status;
    ippFilterScharrVertMaskBorderGetBufferSize(roiSize, ippMskSize3x3, ipp8u, ipp16s, 1, &bufferSize);
```
pBuffer = ippsMalloc_8u(bufferSize);
status = ippiFilterScharrVertMaskBorder_8u16s_C1R(pSrc + srcStep, srcStep, pDst, dstStep, roiSize, ippMskSize3x3,
        borderType, 0, pBuffer);
ippsFree(pBuffer);
return status;
}

The result is as follows:

<p>| | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>32</td>
<td>1925</td>
<td>1925</td>
<td>32</td>
<td>-1117</td>
<td>-1127</td>
<td>22</td>
</tr>
<tr>
<td>16</td>
<td>32</td>
<td>1995</td>
<td>1995</td>
<td>32</td>
<td>-1094</td>
<td>-1097</td>
<td>29</td>
</tr>
<tr>
<td>16</td>
<td>32</td>
<td>2016</td>
<td>2016</td>
<td>32</td>
<td>-1088</td>
<td>-1088</td>
<td>32</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
<td>2019</td>
<td>2019</td>
<td>20</td>
<td>-1082</td>
<td>-1082</td>
<td>20</td>
</tr>
<tr>
<td>-10</td>
<td>-20</td>
<td>2029</td>
<td>2029</td>
<td>-20</td>
<td>-1062</td>
<td>-1062</td>
<td>-20</td>
</tr>
<tr>
<td>-16</td>
<td>-32</td>
<td>2032</td>
<td>2032</td>
<td>-32</td>
<td>-1056</td>
<td>-1056</td>
<td>-32</td>
</tr>
<tr>
<td>-16</td>
<td>-32</td>
<td>2032</td>
<td>2032</td>
<td>-32</td>
<td>-1056</td>
<td>-1056</td>
<td>-32</td>
</tr>
</tbody>
</table>

See Also

Borders in Neighborhood Operations
Regions of Interest in Intel IPP
User-defined Border Types
FilterScharrVertMaskBorderGetBufferSize Computes the size of the work buffer for the Scharr Vertical filter.

FilterSharpenBorderGetBufferSize

Computes the size of the work buffer for image sharpening.

Syntax

IppStatus ippiFilterSharpenBorderGetBufferSize(IppiSize dstRoiSize, IppiMaskSize mask, IppDataType srcDataType, IppDataType dstDataType, int numChannels, int* pBufferSize);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

dstRoiSize
mask
srcDataType
dstDataType
numChannels
pBufferSize

Size of the destination ROI, in pixels.
Predefined mask of IppiMaskSize type. Possible value is ippMskSize3x3.
Data type of the source image.
Data type of the destination image.
Number of channels in the image. Possible values are 1, 3, or 4.
Pointer to the size, in bytes, of the external buffer.
Description
This function computes the size, in bytes, of the external work buffer for the `ippiFilterSharpenBorder` function. The result is stored in the `pBufferSize` parameter.

Return Values
- `ippStsNoErr`: Indicates no error. Any other value indicates an error.
- `ippStsNullPtrErr`: Indicates an error when `pBufferSize` is NULL.
- `ippStsSizeErr`: Indicates an error when `dstRoiSize` has a field with a zero or negative value.
- `ippStsMaskSizeErr`: Indicates an error when `mask` has an illegal value.
- `ippStsDataTypeErr`: Indicates an error when `srcDataType` or `dstDataType` has an illegal value.
- `ippStsNumChannelErr`: Indicates an error when `numChannels` has an illegal value.

See Also
- FilterSharpenBorder: Performs image sharpening with a high-pass filter.

FilterSharpenBorder
*Performs image sharpening with a high-pass filter.*

Syntax
**Case 1: Operating on one-channel data**

IppStatus ippiFilterSharpenBorder_8u_C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp8u borderValue, Ipp8u* pBuffer);

IppStatus ippiFilterSharpenBorder_16s_C1R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp16s borderValue, Ipp8u* pBuffer);

IppStatus ippiFilterSharpenBorder_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp32f borderValue, Ipp8u* pBuffer);

**Case 2: Operating on multi-channel data**

IppStatus ippiFilterSharpenBorder_8u_C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp8u pBorderValue[3], Ipp8u* pBuffer);

IppStatus ippiFilterSharpenBorder_16s_C3R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp16s pBorderValue[3], Ipp8u* pBuffer);

IppStatus ippiFilterSharpenBorder_32f_C3R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp32f pBorderValue[3], Ipp8u* pBuffer);

IppStatus ippiFilterSharpenBorder_8u_AC4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp8u pBorderValue[3], Ipp8u* pBuffer);
IppStatus ippiFilterSharpenBorder_16s_AC4R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp16s pBorderValue[3], Ipp8u* pBuffer);
IppStatus ippiFilterSharpenBorder_32f_AC4R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp32f pBorderValue[3], Ipp8u* pBuffer);
IppStatus ippiFilterSharpenBorder_8u_C4R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp8u pBorderValue[4], Ipp8u* pBuffer);
IppStatus ippiFilterSharpenBorder_16s_C4R(const Ipp16s* pSrc, int srcStep, Ipp16s* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp16s pBorderValue[4], Ipp8u* pBuffer);
IppStatus ippiFilterSharpenBorder_32f_C4R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, const Ipp32f pBorderValue[4], Ipp8u* pBuffer);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc  
Pointer to the source image ROI.

srcStep  
Distance, in bytes, between the starting points of consecutive lines in the source image.

pDst  
Pointer to the destination image ROI.

dstStep  
Distance, in bytes, between the starting points of consecutive lines in the destination image.

dstRoiSize  
Size of the source and destination ROI, in pixels.

mask  
Predefined mask of IppiMaskSize. Possible value is ippMskSize3x3.

borderType  
Type of border. Possible values are:

ippBorderConst  
Values of all border pixels are set to constant.

ippBorderRepl  
Border is replicated from the edge pixels.

ippBorderInMem  
Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, or ippBorderMirror values and the
ippiFilterSharpenBorder

Border Value

*borderValue*

Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

*pBorderValue[3], pBorderValue[4]*

Pointer to constant values to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

*pBuffer*

Pointer to the work buffer.

**Description**

Before using this function, you need to compute the size of the work buffer *pBuffer* using the ippiFilterSharpenBorderGetBufferSize function.

This function operates with ROI (see Regions of Interest in Intel IPP).

This function applies a high-pass filter to the *pSrc* source image ROI. The size of the source image ROI is equal to the destination image ROI size *dstRoiSize*. The values of border pixels are assigned in accordance with the *borderType* and *borderValue* parameters. The kernel of the filter is a matrix of 3x3 size. The kernel has the following value:

<table>
<thead>
<tr>
<th>-1/8</th>
<th>-1/8</th>
<th>-1/8</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1/8</td>
<td>16/8</td>
<td>-1/8</td>
</tr>
<tr>
<td>-1/8</td>
<td>-1/8</td>
<td>-1/8</td>
</tr>
</tbody>
</table>

The anchor cell is the center cell of the kernel, highlighted in red.

**Return Values**

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error when one of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error when *dstRoiSize* is negative, or equal to zero.
- ippStsBorderErr: Indicates an error when *mask* has an illegal value.
- ippStsBorderErr: Indicates an error when *borderType* has an illegal value.

**See Also**

Borders in Neighborhood Operations
Regions of Interest in Intel IPP
User-defined Border Types
FilterSharpenBorder  Performs image sharpening with a high-pass filter.

FilterSobelGetBufferSize

*Computes the size of the work buffer for the Sobel filter.*
Syntax

IppStatus ippiFilterSobelGetBufferSize (IppiSize dstRoiSize, IppiMaskSize mask,
IppNormType normType, IppDataType srcDataType, IppDataType dstDataType, int
numChannels, int* pBufferSize);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

dstRoiSize          Size of the destination ROI in pixels.
mask                Predefined mask of IppiMaskSize type. Possible values are
                    ippMskSize3x3 or ippMskSize5x5.
normType            Normalization mode of IppNormType type.
srcDataType         Data type of the source image.
dstDataType         Data type of the destination image.
numChannels         Number of channels in the image. Possible value is 1.
pBufferSize         Pointer to the size of the external work buffer.

Description

The ippiFilterSobelGetBufferSize function computes the size, in bytes, of the external work buffer
needed for the ippiFilterSobel function. The result is stored in the pBufferSize parameter.

For an example on how to use this functions, see the code example provided with the ippiFilterSobel
function description.

Return Values

ippStsNoErr          Indicates no error.
ippStsNullPtrErr     Indicates an error when pBufferSize is NULL.
ippStsSizeErr        Indicates an error when dstRoiSize is less than, or equal to
                    zero.
ippStsMaskSizeErr    Indicates an error when mask has an illegal value.
ippStsBadArgErr      Indicates an error when normType has an illegal value.
ippStsDataTypeErr    Indicates an error when srcDataType or dstDataType has an illegal
                    value.
ippStsNumChannelsErr Indicates an error when numChannels has an illegal value.

See Also

FilterSobel        Filters an image using a Sobel filter.
FilterSobel
Filters an image using a Sobel filter.

Syntax
IppStatus ippiFilterSobel_<mod>(const Ipp<srcdatatype>* pSrc, int srcStep,
Ipp<dstdatatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize maskSize,
IppNormType normType, IppiBorderType borderType, Ipp<srcdatatype> borderValue, Ipp8u* pBuffer);

Supported values for mod:
8u16s_C1R 16s32f_C1R 16u32f_C1R 32f_C1R

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pSrc
Pointer to the source image ROI.
srcStep
Distance, in bytes, between the starting points of consecutive lines in the source image.

pDst
Pointer to the destination image ROI.
dstStep
Distance, in bytes, between the starting points of consecutive lines in the destination image.
dstRoiSize
Size of the source and destination ROI in pixels.
maskSize
Size of the predefined mask. Possible values are ippMskSize3x3 or ippMskSize5x5.
normType
Normalization mode of IppNormType.

borderType
Type of border. Possible values are:
ippBorderConst  Values of all border pixels are set to constant.
ippBorderRepl Border is replicated from the edge pixels.
ippBorderInMem Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl or ippBorderConst values and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.
### Description

Before using this function, you need to compute the size of the work buffer `pBuffer` using the `ippiFilterSobelBufferSize` function.

This function applies a Sobel filter to the source image with the specified kernel size and normalization type. The values of border pixels are assigned in accordance with the `borderType` and `borderValue` parameters. The kernel of the filter is a matrix of 3x3 or 5x5 size depending on the `maskSize` value. The formulas below describe the algorithm for the 3x3 and 5x5 Sobel operators.

**3x3 Sobel operator:**

\[
G_x = \begin{bmatrix}
1 & 0 & -1 \\
2 & 0 & -2 \\
1 & 0 & -1
\end{bmatrix} \ast A \quad \text{and} \quad G_y = \begin{bmatrix}
1 & 2 & 1 \\
0 & 0 & 0 \\
-1 & -2 & -1
\end{bmatrix} \ast A
\]

**5x5 Sobel operator:**

\[
G_x = \begin{bmatrix}
1 & 2 & 0 & -2 & -1 \\
4 & 8 & 0 & -8 & -4 \\
6 & 12 & 0 & -12 & -6 \\
4 & 8 & 0 & -8 & -4 \\
1 & 2 & 0 & -2 & -1
\end{bmatrix} \ast A \quad \text{and} \quad G_y = \begin{bmatrix}
1 & 4 & 6 & 4 & 1 \\
2 & 8 & 12 & 8 & 2 \\
0 & 0 & 0 & 0 & 0 \\
-2 & -8 & -12 & -8 & -2 \\
-1 & -4 & -6 & -4 & -1
\end{bmatrix} \ast A
\]

where
- `A` is the source image
- `\ast` is the 2D convolution operator
- `G_x` and `G_y` are horizontal and vertical magnitude of the source image, respectively

Sobel filter output `G`, as overall gradient magnitude, is generated through L1 and L2 normalization of `G_x` and `G_y`.

**L1 normalization:**

\[
G = |G_x| + |G_y|
\]

**L2 normalization:**

\[
G = \sqrt{G_x^2 + G_y^2}
\]
Return Values

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error when one of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error when dstRoiSize has a field with a zero or negative value.
- ippStsMaskSizeErr: Indicates an error when maskSize has an illegal value.
- ippStsStepErr: Indicates an error when srcStep or dstStep is less than, or equal to zero.
- ippStsNotEvenStepErr: Indicates an error when one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.
- ippStsBorderErr: Indicates an error when borderType has an illegal value.

Example

The code example below demonstrates how to use the `ippiFilterSobelGetBufferSize` and `ippiFilterSobel_8u16s_C1R` functions.

```c
IppStatus filter_sobel_8u16s_c1( void ) {
    Ipp8u pSrc[9*8] = {
    0, 1, 2, 120, 121, 122, 50, 51, 52,
    1, 2, 3, 121, 122, 123, 52, 52, 53,
    3, 4, 5, 130, 131, 132, 63, 64, 65,
    4, 5, 6, 131, 132, 133, 64, 65, 66,
    5, 6, 7, 132, 133, 134, 65, 66, 67,
    8, 7, 6, 134, 133, 132, 67, 66, 65,
    7, 6, 5, 133, 132, 131, 66, 65, 64,
    6, 5, 4, 132, 131, 130, 65, 64, 63
    };
    Ipp16s   pDst[8*7];
    IppiSize roiSize = {8, 7};
    IppiMaskSize mask = ippMskSize3x3;
    IppiBorderType borderType = ippBorderConst | ippBorderInMemTop | ippBorderInMemRight;
    int     srcStep = 9 * sizeof(Ipp8u);
    int     dstStep = 8 * sizeof(Ipp16s);
    int     bufferSize;
    IppStatus status;
    Ipp8u   *pBuffer;
    IppNormType normType = ippNormL1;

    ippiFilterSobelGetBufferSize(roiSize, mask, normType, ipp8u, ipp16s, 1, &bufferSize);
    pBuffer = ippsMalloc_8u(bufferSize);
    status = ippiFilterSobel_8u16s_C1R(pSrc+srcStep, srcStep, pDst, dstStep, roiSize, mask,
                                       normType, borderType, 33, pBuffer);
    ippsFree(pBuffer);

    return status;
}
```

The result is as follows:

```
pDst -->
   132     20    502    516     48    322    330     58
   126     20    516    530     48    316    322     58
```
See Also
Borders in Neighborhood Operations
Regions of Interest in Intel IPP
User-defined Border Types
FilterSobelGetBufferSize Computes the size of the work buffer for the Sobel filter.

FilterSobelHorizBorderGetBufferSize

Computes the size of the work buffer for the Sobel Horizontal filter.

Syntax
IppStatus ippiFilterSobelHorizBorderGetBufferSize (IppiSize dstRoiSize, IppiMaskSize mask, IppDataType srcDataType, IppDataType dstDataType, int numChannels, int* pBufferSize);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
dstRoiSize
   Size of the destination ROI in pixels.

mask
   Predefined mask of IppiMaskSize type. Possible values are ippMskSize3x3 or ippMskSize5x5.

srcDataType
   Data type of the source image.

dstDataType
   Data type of the destination image.

numChannels
   Number of channels in the image. Possible value is 1.

pBufferSize
   Pointer to the size of the external work buffer.

Description
The ippiFilterSobelHorizBorderGetBufferSize function computes the size, in bytes, of the external work buffer needed for the ippiFilterSobelHorizBorder function. The result is stored in the pBufferSize parameter.

For an example on how to use this functions, see the code example provided with the ippiFilterSobelHorizBorder function description.
Return Values

ippStsNoErr
Indicates no error.

ippStsNullPtrErr
Indicates an error when pBufferSize is NULL.

ippStsSizeErr
Indicates an error when dstRoiSize is negative, or equal to zero.

ippStsMaskSizeErr
Indicates an error when mask has an illegal value.

ippStsDataTypeErr
Indicates an error when srcDataType or dstDataType has an illegal value.

ippStsNumChannelsError
Indicates an error when numChannels has an illegal value.

See Also
FilterSobelHorizBorder Filters an image using a horizontal Sobel filter.

FilterSobelHorizBorder
Filters an image using a horizontal Sobel filter.

Syntax
IppStatus ippiFilterSobelHorizBorder_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp<srcDatatype> borderValue, Ipp8u* pBuffer);

Supported values for mod:
8u16s_C1R 16s_C1R 32f_C1R

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc
Pointer to the source image ROI.
srcStep
Distance, in bytes, between the starting points of consecutive lines in the source image.
pDst
Pointer to the destination image ROI.
dstStep
Distance, in bytes, between the starting points of consecutive lines in the destination image.
dstRoiSize
Size of the source and destination ROI in pixels.
mask
Predefined mask of IppiMaskSize. Possible values are ippMskSize3x3 or ippMskSize5x5.
borderType
Type of border. Possible values are:
Values of all border pixels are set to constant.

Border is replicated from the edge pixels.

Mirrored border is used.

Mirrored border with replication is used.

Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, ippBorderMirror, or ippBorderMirrorR values and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.

Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

Pointer to the work buffer.

Before using this function, you need to compute the size of the work buffer pBuffer using the FilterSobelHorizBorderGetBufferSize function.

This function operates with ROI.

This function applies a horizontal Sobel filter to the pSrc source image ROI. The size of the source image ROI is equal to the destination image ROI size dstRoiSize. The values of border pixels are assigned in accordance with the borderType and borderValue parameters. The kernel of the filter is a matrix of 3x3 or 5x5 size depending on the mask value. The kernels have the following values:

1 4 6 4 1
2 8 12 8 2
0 0 0 or 0 0 0 0 0
-1 -2 -1 -2 -8 -12 -8 -2
-1 -4 -6 -4 -1

The anchor cell is the center cell of the kernel, highlighted in red.

This filter enhances horizontal edges of an image.

Indicates no error.

Indicates an error when one of the specified pointers is NULL.
### Example

The code example below demonstrates how to use the `ippiFilterSobelHorizBorderGetBufferSize` and `ippiFilterSobelHorizBorder_8u16s_C1R` functions to filter an image with the Sobel horizontal kernel.

```c
IppStatus fix_sobelhoriz_8u16( void ) {
    Ipp8u pSrc[9*8] = {
        0, 1, 2, 120, 121, 122, 50, 51, 52,
        1, 2, 3, 121, 122, 123, 52, 52, 53,
        3, 4, 5, 130, 131, 132, 63, 64, 65,
        4, 5, 6, 131, 132, 133, 64, 65, 66,
        5, 6, 7, 132, 133, 134, 65, 66, 67,
        8, 7, 6, 134, 133, 132, 67, 66, 65,
        6, 5, 4, 133, 132, 131, 66, 65, 64,
        7, 6, 5, 132, 131, 130, 65, 64, 63
    };
    Ipp16s  pDst[8*7];
    Ipp8u   *pBuffer;
    IppiSize roiSize = {8, 7};
    IppiBorderType borderType = ippBorderRepl | ippBorderInMemTop | ippBorderInMemRight;
    int    srcStep = 9 * sizeof(Ipp8u);
    int    dstStep = 8 * sizeof(Ipp16s);
    int    bufferSize;
    IppStatus status;
    ippiFilterSobelHorizBorderGetBufferSize(roiSize, ippMskSize3x3, ipp8u, ipp16s, 1,
        &bufferSize);
    pBuffer = ippsMalloc_8u(bufferSize);
    status = ippiFilterSobelHorizBorder_8u16s_C1R(pSrc + srcStep, srcStep, pDst, dstStep,
        roiSize, ippMskSize3x3,
        borderType, 0, pBuffer);
    ippsFree(pBuffer);
    return status;
}
```

The result is as follows:

```
pDst -->
12 12 19 33 40 43 49 52
12 12 19 33 40 42 47 51
8 8 8 8 8 8 8 8
18 8 5 7 4 2 6 4
6 0 -3 -1 -4 -6 -2 -4
-8 -8 -8 -8 -8 -8 -8 -8
-4 -4 -4 -4 -4 -4 -4 -4
```

### See Also

- Borders in Neighborhood Operations
- Regions of Interest in Intel IPP
User-defined Border Types
FilterSobelHorizBorderGetBufferSize Computes the size of the work buffer for the Sobel Horizontal filter.

FilterSobelHorizSecondBorderGetBufferSize
Computes the size of the work buffer for the Sobel Horizontal (second derivative) filter.

Syntax
IppStatus ippiFilterSobelHorizSecondBorderGetBufferSize (IppSize dstRoiSize,
IppiMaskSize mask, IppDataType srcDataType, IppDataType dstDataType, int numChannels,
int* pBufferSize);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

dstRoiSize Size of the destination ROI in pixels.

mask Predefined mask of IppiMaskSize type. Possible values are ippMskSize3x3 or ippMskSize5x5.

srcDataType Data type of the source image.

dstDataType Data type of the destination image.

numChannels Number of channels in the image. Possible value is 1.

pBufferSize Pointer to the size of the external work buffer.

Description
The ippiFilterSobelHorizSecondBorderGetBufferSize function computes the size, in bytes, of the external work buffer needed for the ippiFilterSobelHorizSecondBorder function. The result is stored in the pBufferSize parameter.

Return Values
ippStsNoErr Indicates no error.

ippStsNullPtrErr Indicates an error when pBufferSize is NULL.

ippStsSizeErr Indicates an error when dstRoiSize is negative, or equal to zero.

ippStsMaskSizeErr Indicates an error when mask has an illegal value.

ippStsDataTypeErr Indicates an error when srcDataType or dstDataType has an illegal value.

ippStsNumChannelsError Indicates an error when numChannels has an illegal value.
See Also
FilterSobelHorizSecondBorder  Applies horizontal (second derivative) Sobel filter with border.

FilterSobelHorizSecondBorder
Applies horizontal (second derivative) Sobel filter with border.

Syntax
IppStatus ippiFilterSobelHorizSecondBorder_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp<srcDatatype> borderValue, Ipp8u* pBuffer);

Supported values for mod:
8u16s_C1R  32f_C1R

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pSrc  Pointer to the source image ROI.
srcStep  Distance in bytes between starts of consecutive lines in the source image.
pDst  Pointer to the destination image ROI.
dstStep  Distance in bytes between starts of consecutive lines in the destination image.
dstRoiSize  Size of the source and destination image ROI.
mask  Type of the filter kernel.
borderType  Type of border (see Borders in Neighborhood Operations); following values are possible:
ippBorderConst  Values of all border pixels are set to constant.
ippBorderRepl  Replicated border is used.
ippBorderMirror  Mirrored border is used
ippBorderMirrorR  Mirrored border with replication is used
borderValue  The constant value to assign to the pixels in the constant border (not applicable for other border's type).
pBuffer  Pointer to the working buffer.
Description

This function operates with ROI (see Regions of Interest in Intel IPP). This function applies the second
derivative horizontal Sobel filter ($y$-derivative) to the source image $pSrc$ and stores results to the destination
image of the same size $pDst$. Source image can be used as the destination image if they both have the same
data type. The values of border pixels are assigned in accordance with the $borderType$ and $borderValue$
parameters. The kernel of this filter is the matrix of either 3x3 or 5x5 size that is specified by the parameter
$mask$. The kernels have the following values with the anchor in the center cell (red):

<table>
<thead>
<tr>
<th>1   4   6   4   1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  2  1</td>
</tr>
<tr>
<td>0  0  0  0  0</td>
</tr>
<tr>
<td>-2 -4 -2 or</td>
</tr>
<tr>
<td>-2 -8 -12 -8 -2</td>
</tr>
<tr>
<td>1  2  1</td>
</tr>
<tr>
<td>0  0  0  0  0</td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>1   4   6   4   1</td>
</tr>
</tbody>
</table>

The function requires the working buffer $pBuffer$ which size should be computed by the function

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if $roiSize$ has a field with a zero or negative value.
- **ippStsStepErr**: Indicates an error condition if $srcStep$ or $dstStep$ is less than $roiSize.width * <pixelSize>$.
- **ippStsNotEvenStepErr**: Indicates an error condition if one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.
- **ippStsBadArgErr**: Indicates an error if $borderType$ or $divisor$ has a wrong value.
- **ippStsMaskErr**: Indicates an error condition if $mask$ has a wrong value.

FilterSobelVertBorderGetBufferSize

*Computes the size of the work buffer for the Sobel Vertical filter.*

Syntax

```c
IppStatus ippiFilterSobelVertBorderGetBufferSize (IppiSize dstRoiSize, IppiMaskSize mask, IppDataType srcDataType, IppDataType dstDataType, int numChannels, int* pBufferSize);
```

Include Files

ippi.h

Parameters

- **dstRoiSize**: Size of the destination ROI in pixels.
mask

Predefined mask of IppiMaskSize type. Possible values are ippMskSize3x3 or ippMskSize5x5.

srcDataType

Data type of the source image.

dstDataType

Data type of the destination image.

numChannels

Number of channels in the image. Possible value is 1.

pBufferSize

Pointer to the size of the external work buffer.

Description

The ippiFilterSobelVertBorderGetBufferSize function computes the size, in bytes, of the external work buffer needed for the ippiFilterSobelVertBorder function. The result is stored in the pBufferSize parameter.

For an example on how to use this function, see the code example provided with the ippiFilterSobelVertBorder function description.

Return Values

ippStsNoErr

Indicates no error.

ippStsNullPtrErr

Indicates an error when pBufferSize is NULL.

ippStsSizeErr

Indicates an error when dstRoiSize is negative, or equal to zero.

ippStsMaskSizeErr

Indicates an error when mask has an illegal value.

ippStsDataTypeErr

Indicates an error when srcDataType or dstDataType has an illegal value.

ippStsNumChannelsError

Indicates an error when numChannels has an illegal value.

See Also

FilterSobelVertBorder Filters an image using a vertical Sobel filter.

FilterSobelVertBorder

Filters an image using a vertical Sobel filter.

Syntax

IppStatus ippiFilterSobelVertBorder_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp<srcDatatype> borderValue, Ipp8u* pBuffer);

Supported values for mod:

8u16s_C1R 16s_C1R 32f_C1R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance, in bytes, between the starting points of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance, in bytes, between the starting points of consecutive lines in the destination image.
- **dstRoiSize**: Size of the source and destination ROI in pixels.
- **mask**: Predefined mask of IppiMaskSize. Possible values are ippMskSize3x3 or ippMskSize5x5.
- **borderType**: Type of border. Possible values are:
  - ippBorderConst: Values of all border pixels are set to constant.
  - ippBorderRepl: Border is replicated from the edge pixels.
  - ippBorderMirror: Mirrored border is used.
  - ippBorderMirrorR: Mirrored border with replication is used.
  - ippBorderInMem: Border is obtained from the source image pixels in memory.

  Mixed borders are also supported. They can be obtained by the bitwise operation OR between any of the ippBorderRepl, ippBorderConst, ippBorderMirror, or ippBorderMirrorR values and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.
- **borderValue**: Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.
- **pBuffer**: Pointer to the work buffer.

Description

Before using this function, you need to compute the size of the work buffer **pBuffer** using the FilterSobelVertBorderGetBufferSize function.

This function operates with ROI.
This function applies a vertical Sobel filter to the \texttt{pSrc} source image ROI. The size of the source image ROI is equal to the destination image ROI size \texttt{dstRoiSize}. The values of border pixels are assigned in accordance with the \texttt{borderType} and \texttt{borderValue} parameters. The kernel of the filter is a matrix of 3x3 or 5x5 size depending on the \texttt{mask} value. The kernels have the following values:

\begin{verbatim}
-1 -2 0 2 1
-1 0 1 -4 -8 0 8 4
-2 0 2 or -6 -12 0 12 6
-1 0 1 -4 -8 0 8 4
-1 -2 0 2 1
\end{verbatim}

The anchor cell is the center cell of the kernel, highlighted in red.

This filter enhances vertical edges of an image.

**Return Values**

- \texttt{ippStsNoErr} Indicates no error.
- \texttt{ippStsNullPtrErr} Indicates an error when one of the specified pointers is \texttt{NULL}.
- \texttt{ippStsSizeErr} Indicates an error when \texttt{dstRoiSize} is negative, or equal to zero.
- \texttt{ippStsStepErr} Indicates an error when \texttt{srcStep} or \texttt{dstStep} is negative, or equal to zero.
- \texttt{ippStsNotEvenStepErr} Indicates an error when one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.
- \texttt{ippStsBorderErr} Indicates an error when \texttt{borderType} has an illegal value.

**Example**

The code example below demonstrates how to use the \texttt{ippiFilterSobelVertBorderGetBufferSize} and \texttt{ippiFilterSobelVertBorder} functions.

```c
IppStatus fix_sobel_8u16( void ) {
    Ipp8u pSrc[9*8] =
    {
        0, 1, 2, 120, 121, 122, 50, 51, 52,
        1, 2, 3, 121, 122, 123, 52, 53, 53,
        3, 4, 5, 130, 131, 132, 63, 64, 65,
        4, 5, 6, 131, 132, 133, 64, 65, 66,
        5, 6, 7, 132, 133, 134, 65, 66, 67,
        8, 7, 6, 134, 133, 132, 67, 66, 65,
        7, 6, 5, 133, 132, 131, 66, 65, 64,
        6, 5, 4, 132, 131, 130, 65, 64, 63
    };
    Ipp16s pDst[8*7];
    Ipp8u *pBuffer;
   ippiSize roiSize = {8, 7};
   ippiBorderType borderType = ippBorderRepl | ippBorderInMemTop | ippBorderInMemRight;
    int srcStep = 9 * sizeof(Ipp8u);
    int dstStep = 8 * sizeof(Ipp16s);
    int bufferSize;
    IppStatus status;
    ippFilterSobelVertBorderGetBufferSize(roiSize, ippMskSize3x3, ippi8u, ippi16s, 1,
```
The result is as follows:

```
pDst ->
-4 -8 -483 -483 -8 279 281 -6
-4 -8 -497 -497 -8 274 275 -7
-4 -8 -504 -504 -8 272 272 -8
-2 -4 -505 -505 -4 270 270 -4
 2 4 -507 -507  4 266 266  4
 4 8 -508 -508  8 264 264   8
 4 8 -508 -508  8 264 264   8
```

See Also
Borders in Neighborhood Operations
Regions of Interest in Intel IPP
User-defined Border Types
FilterSobelVertBorderGetBufferSize Computes the size of the work buffer for the Sobel Vertical filter.

**FilterSobelVertSecondBorderGetBufferSize**

*Computes the size of the work buffer for the Sobel vertical (second derivative) filter.*

**Syntax**

```
IppStatus ippiFilterSobelVertSecondBorderGetBufferSize (IppiSize dstRoiSize,
IppiMaskSize mask, IppDataType srcDataType, IppDataType dstDataType, int numChannels,
int* pBufferSize);
```

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- `dstRoiSize`
  Size of the destination ROI in pixels.

- `mask`
  Predefined mask of IppiMaskSize type. Possible values are ippMskSize3x3 or ippMskSize5x5.

- `srcDataType`
  Data type of the source image.

- `dstDataType`
  Data type of the destination image.
**numChannels**
Number of channels in the image. Possible value is 1.

**pBufferSize**
Pointer to the size of the external work buffer.

**Description**
The `ippiFilterSobelVertSecondBorderGetBufferSize` function computes the size, in bytes, of the external work buffer needed for the `ippiFilterSobelVertSecondBorder` function. The result is stored in the `pBufferSize` parameter.

**Return Values**

- **ippStsNoErr**
  Indicates no error.

- **ippStsNullPtrErr**
  Indicates an error when `pBufferSize` is NULL.

- **ippStsSizeErr**
  Indicates an error when `dstRoiSize` is negative, or equal to zero.

- **ippStsMaskSizeErr**
  Indicates an error when `mask` has an illegal value.

- **ippStsDataTypeErr**
  Indicates an error when `srcDataType` or `dstDataType` has an illegal value.

- **ippStsNumChannelsError**
  Indicates an error when `numChannels` has an illegal value.

**See Also**
*FilterSobelVertSecondBorder* Applies vertical (second derivative) Sobel filter with border.

*FilterSobelNegVertBorderGetBufferSize*
**Computes the size of the work buffer for the Sobel vertical filter.**

**Syntax**
```c
IppStatus ippiFilterSobelNegVertBorderGetBufferSize (IppiSize dstRoiSize, IppiMaskSize mask, IppDataType srcDataType, IppDataType dstDataType, int numChannels, int* pBufferSize);
```

**Include Files**
ippi.h

**Domain Dependencies**
*Headers:* ippcore.h, ippvm.h, ipps.h
*Libraries:* ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **dstRoiSize**
  Size of the destination ROI in pixels.

- **mask**
  Predefined mask of `IppiMaskSize` type. Possible values are `ippMskSize3x3` or `ippMskSize5x5`.

- **srcDataType**
  Data type of the source image.

- **dstDataType**
  Data type of the destination image.
numChannels

Number of channels in the image. Possible value is 1.

pBufferSize

Pointer to the size of the external work buffer.

Description

The `ippiFilterSobelVertSecondBorderGetBufferSize` function computes the size, in bytes, of the external work buffer needed for the `ippiFilterSobelNegVertBorder` function. The result is stored in the `pBufferSize` parameter.

Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error when `pBufferSize` is NULL.
- **ippStsSizeErr**: Indicates an error when `dstRoiSize` is negative, or equal to zero.
- **ippStsMaskSizeErr**: Indicates an error when `mask` has an illegal value.
- **ippStsDataTypeErr**: Indicates an error when `srcDataType` or `dstDataType` has an illegal value.
- **ippStsNumChannelsError**: Indicates an error when `numChannels` has an illegal value.

See Also

FilterSobelNegVertSecondBorder  Applies vertical Sobel filter with border.

FilterSobelNegVertBorder

 Applies vertical Sobel filter with border.

Syntax

```c
IppStatusippiFilterSobelNegVertBorder_<mod>(const Ipp<srcDataType>* pSrc, int srcStep, Ipp<dstDataType>* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp<srcDataType> borderValue, Ipp8u* pBuffer);
```

Supported values for `mod`:

- 8u16s_C1R
- 32f_C1R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.


**Description**

These functions operate with ROI (see Regions of Interest in Intel IPP). These functions apply the vertical Sobel filter (x-derivative) to the source image ROI `pSrc` and stores results to the destination image ROI of the same size `pDst`. Source image can be used as the destination image if they have the same data type. The values of border pixels are assigned in accordance with the `borderType` and `borderValue` parameters.

The kernel of this filter is the matrix of either 3x3 or 5x5 size that is specified by the parameter `mask`. The anchor cell is the center cell of the kernel (red).

The function `ippiFilterSobelVertBorder` uses the kernels with the following coefficients:

```
-1   -2   0   2   1
-2   0   1
-1   0   1
-1   -2   0   2   1
```

The function `ippiFilterSobelNegVertBorder` uses the kernels which coefficients are the same in magnitude but opposite in sign:

```
1   2   0   -2   -1
1   0   -1
2   0   -2   or
1   0   -1
1   2   0   -2   -1
```

Before using this function, compute the size of the work buffer `pBuffer` using the `FilterSobelNegVertBorderGetBufferSize` function.
Example shows how the function ippiFilterSobelNegVertBorder_8u16s_C1R can be used for edge detection.

Return Values

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error condition if one of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error condition if roiSize has a field with a zero or negative value.
- ippStsStepErr: Indicates an error condition if srcStep or dstStep is less than roiSize.width * pixelSize.
- ippStsNotEvenStepErr: Indicates an error condition if one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.
- ippStsBadArgErr: Indicates an error if borderType or divisor has a wrong value.
- ippStsMaskErr: Indicates an error condition if mask has a wrong value.

See Also

User-defined Border Types

FilterSobelVertSecondBorder

Applies vertical (second derivative) Sobel filter with border.

Syntax

IppStatus ippiFilterSobelVertSecondBorder_<mod>({const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp<srcDatatype> borderValue, Ipp8u* pBuffer});

Supported values for mod:

- 8u16s_C1R
- 32f_C1R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- pSrc: Pointer to the source image ROI.
- srcStep: Distance in bytes between starts of consecutive lines in the source image.
- pDst: Pointer to the destination image ROI.
**Description**

This function operates with ROI (see Regions of Interest in Intel IPP). This function applies the second derivative vertical Sobel filter \((x\text{-derivative})\) to the source image \(p\text{Src}\) and stores results to the destination image of the same size \(p\text{Dst}\). Source image can be used as the destination image if they both have the same data type. The values of border pixels are assigned in accordance with the \(\text{borderType}\) and \(\text{borderValue}\) parameters. The kernel of this filter is the matrix of either 3x3 or 5x5 size that is specified by the parameter \(\text{mask}\). The kernels have the following values with the anchor in the center cell (red):

\[
\begin{array}{c c c c c}
1 & 0 & -2 & 0 & 1 \\
1 & -2 & 1 & 4 & 0 & -8 & 0 & 4 \\
2 & -4 & 2 & 6 & 0 & -12 & 0 & 6 \\
1 & -2 & 1 & 4 & 0 & -8 & 0 & 4 \\
1 & 0 & -2 & 0 & 1 
\end{array}
\]

The function requires the working buffer \(p\text{Buffer}\) which size should be computed by the function \(\text{ippiFilterSobelVertSecondBorderGetBufferSize}\) beforehand.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if \(\text{roiSize}\) has a field with a zero or negative value.
- **ippStsStepErr**: Indicates an error condition if \(\text{srcStep}\) or \(\text{dstStep}\) is less than \(\text{roiSize.width} \times <\text{pixelSize}>\).
ippStsNotEvenStepErr  Indicates an error condition if one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.

ippStsBadArgErr  Indicates an error if borderType or divisor has a wrong value.

ippStsMaskErr  Indicates an error condition if mask has a wrong value.

Example
To better understand usage of this function, refer to the FilterSobelVertSecondBorder.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

FilterSobelCrossGetBufferSize
Computes the size of the external buffer for the cross Sobel filter with border.

Syntax
IppStatus ippiFilterSobelCrossGetBufferSize_<mod>(IppSize roiSize, IppiMaskSize mask, int* pBufferSize);

Supported values for mod:

8u16s_C1R  32f_C1R

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters
roiSize  Maximum size of the source and destination image ROI.
mask  Predefined mask of IppiMaskSize type.
pBufferSize  Pointer to the buffer size.

Description
This function computes the size of the external buffer that is required for the filter function ippiFilterSobelCrossBorder. The kernel of the filter is the matrix of either 3x3 or 5x5 size that is specified by the parameter mask (see Table “Types of the Fixed Filter Functions”). This buffer pBufferSize[0] can be used to filter an image whose width and height are equal to or less than corresponding fields of roiSize.

Return Values
ippStsNoErr  Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr  Indicates an error condition if the pBufferSize pointer is NULL.
FilterSobelCrossBorder

Applies second derivative cross Sobel filter with border.

Syntax

IppStatus ippiFilterSobelCrossBorder_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize roiSize, IppiMaskSize mask, IppiBorderType borderType, Ipp<srcDatatype> borderValue, Ipp8u* pBuffer);

Supported values for mod:

8u16s_C1R  32f_C1R

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc
Pointer to the source image ROI.

csrcStep
Distance in bytes between starts of consecutive lines in the source image.

pDst
Pointer to the destination image ROI.

dstStep
Distance in bytes between starts of consecutive lines in the destination image.

roiSize
Size of the source and destination image ROI.

mask
Type of the filter kernel.

borderType
Type of border (see Borders in Neighborhood Operations); following values are possible:

ippBorderConst  Values of all border pixels are set to constant.
ippBorderRepl   Replicated border is used.

borderValue
The constant value to assign to the pixels in the constant border (not applicable for other border's type).

pBuffer
Pointer to the working buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

ippStsSizeErr
Indicates an error condition if roiSize has a field with a zero or negative value.

ippStsMaskSizeErr
Indicates an error condition if mask has a wrong value.
This function applies the second derivative cross Sobel filter (xy-derivative) to the source image \( p_{Src} \) and stores results to the destination image of the same size \( p_{Dst} \). Source image can be used as the destination image if they both have the same data type. The values of border pixels are assigned in accordance with the \( \text{borderType} \) and \( \text{borderValue} \) parameters. The kernel of this filter is the matrix of either 3x3 or 5x5 size that is specified by the parameter \( \text{mask} \). The kernels have the following values with the anchor in the center cell (red):

\[
\begin{array}{ccc}
-1 & -2 & 0 & 2 & 1 \\
-1 & 0 & 1 & -2 & -4 & 0 & 4 & 2 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & -1 & 2 & 4 & 0 & -4 & -2 \\
1 & 2 & 0 & -2 & -1 \\
\end{array}
\]

The function requires the working buffer \( p_{Buffer} \) whose size should be computed by the function \( \text{ippiFilterSobelCrossGetBufferSize} \) beforehand.

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**
  Indicates an error condition if one of the specified pointers is NULL.

- **ippStsSizeErr**
  Indicates an error condition if \( \text{roiSize} \) has a field with a zero or negative value.

- **ippStsStepErr**
  Indicates an error condition if \( \text{srcStep} \) or \( \text{dstStep} \) is less than \( \text{roiSize.width} \times <\text{pixelSize}> \).

- **ippStsNotEvenStepErr**
  Indicates an error condition if one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.

- **ippStsBadArgErr**
  Indicates an error if \( \text{borderType} \) or \( \text{divisor} \) has a wrong value.

- **ippStsMaskErr**
  Indicates an error condition if \( \text{mask} \) has a wrong value.

---

**GenSobelKernel**

*Computes kernel for the Sobel filter.*

**Syntax**

\[
\text{IppStatus ippiGenSobelKernel\_16s(Ipp16s* pDst, int kernelSize, int dx, int sign);} \\
\text{IppStatus ippiGenSobelKernel\_32f(Ipp32f* pDst, int kernelSize, int dx, int sign);} \\
\]

**Include Files**

ippcv.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Parameters

$pDst$ Pointer to the destination vector.

$kernelSize$ Size of the Sobel kernel.

$dx$ Order of derivative.

$sign$ Specifies signs of kernel elements.

Description

This function computes the one-dimensional Sobel kernel. Kernel coefficients are equal to coefficients of the polynomial

$$(1 + x)^{kernelSize-dx-1} \cdot (x - 1)^{dx}$$

If the $sign$ parameter is negative, then signs of kernel coefficients are changed. Kernel calculated by this function can be used to filter images by a high order Sobel filter.

Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr Indicates an error condition if the $pDst$ pointer is NULL.

ippStsSizeErr Indicates an error condition if $kernelSize$ is less than 3 or is even.

ippStsBadArgErr Indicates an error condition if $dx$ is equal to or less than $kernelSize$, or $dx$ is negative.

Deinterlacing Filters

This section describes functions that perform image deinterlacing.

DeinterlaceFilterCAVT

Performs deinterlacing of two-field image.

Syntax

IppStatus ippiDeinterlaceFilterCAVT_8u_C1R(const Ipp8u* $pSrc$, int $srcStep$, Ipp8u* $pDst$, int $dstStep$, Ipp16u $threshold$, IppiSize $roiSize$);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

$pSrc$ Pointer to the source image ROI.
srcStep

Distance in bytes between starts of consecutive lines in the source image.

pDst

Pointer to the destination image ROI.

dstStep

Distance in bytes between starts of consecutive lines in the destination image.

threshold

Threshold level value.

roiSize

Size of the source and destination image ROI.

Description

This function operates with ROI (see Regions of Interest in Intel IPP). This function performs deinterlacing of a two-field image, pointed to by pSrc, using content adaptive vertical temporal (CAVT) filtering.

The field pointed to by pSrc is copied to pDst, while the other field in the destination image, pointed to by pDst+dstStep, is the interpolated one. Note that you can set the pointers to the bottom left corner of the images and use negative steps to have the bottom field unchanged and the top one interpolated.

The threshold parameter is the edge detection threshold with the valid range [0-2041] regulating the probability of temporal interpolation: 0 means that all the pixels are interpolated only spatially, from the vertically neighbouring pixels of the copied field, 2041 - that combined spatial-temporal interpolation, involving the pixels from the modified field as well, is applied to all the pixels.

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error.

ippStsNullPtrErr

Indicates an error condition if one of the specified pointers is NULL.

ippStsSizeErr

Indicates an error condition if roiSize.width is less than or equal to 0, or roiSize.height is odd or less than 8.

Median

Creating an image consisting of median values of three source images.

Syntax

IppStatus ippiMedian_8u_P3C1R(const Ipp8u* pSrc[3], int srcStep, Ipp8u* pDst, int dstStep, IppiSize size);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc

Array of pointers to the ROI in each plane of the source image.
**srcStep**
Distance in bytes between starts of consecutive lines in each plane of the source image.

**pDst**
Pointer to the destination image ROI.

**dstStep**
Distance in bytes between starts of consecutive lines in the destination image.

**size**
Size of the source and destination image ROI.

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP). This function sets each pixel in the destination image ROI as the median value of correspondent pixels in the each plane of the source image.

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error.

- **ippStsNullPtrErr**
  Indicates an error condition if one of the specified pointers is **NULL**.

- **ippStsSizeErr**
  Indicates an error condition if **size** has a field with zero or negative value.
This chapter describes the Intel® IPP image processing functions that perform linear transform operations on an image buffer. These operations include Fast Fourier Transform (FFT), Discrete Fourier Transform (DFT), and Discrete Cosine Transform (DCT).

To speed up performance, linear transform functions use precomputed auxiliary data that is needed for computation of the transforms (that is, tables of twiddle factors for FFT functions). This data is calculated by the respective initialization functions and passed to the transform functions in context structures specific for each type of transform.

Intel IPP linear transform functions can use external work buffers for storing data and intermediate results, which eliminates the need to allocate and free internal memory buffers and thus helps to further increase function performance. To determine the required work buffer size, use one of the respective support functions specific for each transform type. In case when no external buffer is specified, the transform functions handle memory allocation internally.

All Intel IPP linear transform functions except DCT of 8x8 size work on images with floating-point data only.

**Fourier Transforms**

Intel IPP functions that compute FFT and DFT can process both real and complex images. Function flavors operating on real data are distinguished by R suffix present in function-specific modifier of their full name, whereas complex flavors' names include C suffix (see Function Naming in Chapter 2).

The results of computing the Fourier transform can be normalized by specifying the appropriate value of flag argument for context initialization. This parameter sets up a pair of matched normalization factors to be used in forward and inverse transforms as listed in the following table:

<table>
<thead>
<tr>
<th>Value of flag Argument</th>
<th>Normalization Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPP_FFT_DIV_FWD_BY_N</td>
<td>1/MN</td>
</tr>
<tr>
<td>IPP_FFT_DIV_INV_BY_N</td>
<td>1</td>
</tr>
<tr>
<td>IPP_FFT_DIV_BY_SQRTN</td>
<td>1/sqrt(MN)</td>
</tr>
<tr>
<td>IPP_FFT_NODIV_BY_ANY</td>
<td>1</td>
</tr>
</tbody>
</table>

In this table, \( N \) and \( M \) denote the length of Fourier transform in the x- and y-directions, respectively (or, equivalently, the number of columns and rows in the 2D array being transformed).

For the FFT, these lengths must be integer powers of 2, that is \( N=2^{order_X}, M=2^{order_Y} \), where power exponents are known as order of FFT.

For the DFT, \( N \) and \( M \) can take on arbitrary integer non-negative values.

**Real - Complex Packed (RCPack2D) Format**

The forward Fourier transform of a real two-dimensional image data yields a matrix of complex results which has conjugate-symmetric properties. Intel IPP functions use packed format RCPack2D for storing and retrieving data of this type. Accordingly, real flavors of the inverse Fourier transform functions convert packed complex conjugate-symmetric data back to its real origin. The RCPack2D format exploits the complex conjugate symmetry of the transformed data to store only a half of the resulting Fourier coefficients. For the \( N \) by \( M \) transform, the respective FFT and DFT functions actually store real and imaginary parts of the
complex Fourier coefficients $A(i,j)$ for $i = 0,\ldots,M-1; j = 0,\ldots,N/2$ in a single real array of dimensions $(N,M)$. The RCPack2D storage format is slightly different for odd and even $M$ and is arranged in accordance with the following tables:

**RCPack2D Storage for Odd Number of Rows**

<table>
<thead>
<tr>
<th>Re $A(0,0)$</th>
<th>Re $A(0,1)$</th>
<th>Im $A(0,1)$</th>
<th>...</th>
<th>Re $A(0, (N-1)/2)$</th>
<th>Im $A(0, (N-1)/2)$</th>
<th>Re $A(0, N/2)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re $A(1,0)$</td>
<td>Re $A(1,1)$</td>
<td>Im $A(1,1)$</td>
<td>...</td>
<td>Re $A(1, (N-1)/2)$</td>
<td>Im $A(1, (N-1)/2)$</td>
<td>Re $A(1, N/2)$</td>
</tr>
<tr>
<td>Im $A(1,0)$</td>
<td>Re $A(2,1)$</td>
<td>Im $A(2,1)$</td>
<td>...</td>
<td>Re $A(2, (N-1)/2)$</td>
<td>Im $A(2, (N-1)/2)$</td>
<td>Im $A(2, N/2)$</td>
</tr>
</tbody>
</table>
| ... | ... | ... | ... | ... | ... | ...
| Re $A(M/2,0)$ | Re $A(M-2,1)$ | Im $A(M-2,1)$ | ... | Re $A(M-2, (N-1)/2)$ | Im $A(M-2, (N-1)/2)$ | A($M/2, N/2)$ |

**RCPack2D Storage for Even Number of Rows**

<table>
<thead>
<tr>
<th>Re $A(0,0)$</th>
<th>Re $A(0,1)$</th>
<th>Im $A(0,1)$</th>
<th>...</th>
<th>Re $A(0, (N-1)/2)$</th>
<th>Im $A(0, (N-1)/2)$</th>
<th>Re $A(0, N/2)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re $A(1,0)$</td>
<td>Re $A(1,1)$</td>
<td>Im $A(1,1)$</td>
<td>...</td>
<td>Re $A(1, (N-1)/2)$</td>
<td>Im $A(1, (N-1)/2)$</td>
<td>Re $A(1, N/2)$</td>
</tr>
<tr>
<td>Im $A(1,0)$</td>
<td>Re $A(2,1)$</td>
<td>Im $A(2,1)$</td>
<td>...</td>
<td>Re $A(2, (N-1)/2)$</td>
<td>Im $A(2, (N-1)/2)$</td>
<td>Im $A(2, N/2)$</td>
</tr>
</tbody>
</table>
| ... | ... | ... | ... | ... | ... | ...
| Re $A(M/2-1,0)$ | Re $A(M-3,1)$ | Im $A(M-3,1)$ | ... | Re $A(M-3, (N-1)/2)$ | Im $A(M-3, (N-1)/2)$ | A($M/2, N/2)$ |

The shaded columns to the right side of the tables indicate values for even $N$ only.

Note the above tables show the arrangement of coefficients for one channel. For multichannel images the channel coefficients are clustered and stored consecutively, for example, for 3-channel image they are stored in the following way: $C1$-$ReA(0,0)$; $C2$-$ReA(0,0)$; $C3$-$ReA(0,0)$; $C1$-$ReA(0,1)$; $C2$-$ReA(0,1)$; $C3$-$ReA(0,1)$; $C1$-$ImA(0,1)$; $C2$-$ImA(0,1)$; ...

The remaining Fourier coefficients are obtained using the following relationships based on conjugate-symmetric properties:

$$A(i,j) = \text{conj}(A(M-i,N-j)), \quad i = 1,\ldots,M-1; \quad j = 1,\ldots,N-1$$

$$A(0,j) = \text{conj}(A(0,N-j)), \quad j = 1,\ldots,N-1$$

$$A(i,0) = \text{conj}(A(M-i,0)), \quad i = 1,\ldots,M-1$$

**FFTGetSize**

*Computes the size of the FFT context structure and the size of the work buffer.*

**Syntax**

```c
IppStatus ippiFFTGetSize_R_32f (int orderX, int orderY, int flag, IppHintAlgorithm hint, int* pSizeSpec, int* pSizeInit, int* pSizeBuf);

IppStatus ippiFFTGetSize_C_32fc (int orderX, int orderY, int flag, IppHintAlgorithm hint, int* pSizeSpec, int* pSizeInit, int* pSizeBuf);
```
Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

orderX, orderY
Order of the FFT in x- and y- directions, respectively.

flag
Flag to choose the option for results normalization.

hint
This parameter is deprecated. Set the value to ippAlgHintNone.

pSizeSpec
Pointer to the size of the FFT context structure.

pSizeInit
Pointer to the size of the buffer for the FFT initialization function.

pSizeBuf
Pointer to the size of the FFT external work buffer.

Description
This function computes the following:
- Size of the FFT context structure. The result in bytes is stored in the pSpecSize parameter.
- Size of the work buffer for the ippiFFTInit functions. The result in bytes is stored in the pSizeInit parameter.
- Size of the work buffer for the ippiFFTFwd and ippiFFTInv functions. The result in bytes is stored in the pSizeBuf parameter.

The suffix after the function name indicates the flavors of the FFT functions: ippiFFTGetSize_C is for complex flavors and ippiFFTGetSize_R is for real flavors.

Return Values

ippStsNoErr Indicates no error.
ippStsNullPtrErr Indicates an error when one of the specified pointers is NULL.
ippStsFftOrderErr Indicates an error condition when the FFT order value is illegal.
ippStsFFTFlagErr Indicates an error condition when the flag value is illegal.

See Also

FFTInit Initializes the context structure for the image FFT functions.
FFTInv Applies an inverse FFT to complex source data and stores results in a destination image.
FFTFwd Applies forward Fast Fourier Transform to an image.

FFTInit
Initializes the context structure for the image FFT functions.

Syntax
IppStatus ippiFFTInit_R_32f (int orderX, int orderY, int flag, IppHintAlgorithm hint, IppiFFTSpec_R_32f* pFFTSpec, Ipp8u* pMemInit);
IppStatus ippiFFTInit_C_32fc (int orderX, int orderY, int flag, IppHintAlgorithm hint,
    IppFFTSpec_C_32fc* pFFTSpec, Ipp8u* pMemInit);

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **orderX, orderY**
  Order of the FFT in x- and y- directions, respectively.

- **flag**
  Flag to choose the option for results normalization.

- **hint**
  This parameter is deprecated. Set the value to ippAlgHintNone.

- **pFFTSpec**
  Pointer to the FFT context structure.

- **pMemInit**
  Pointer to the temporary work buffer.

**Description**

This function initializes the `pFFTSpec` context structure needed to compute the forward and inverse FFT of a two-dimensional image data.

Before calling this function, you need to allocate memory for the FFT context structure and temporary work buffer (if it is required). To compute the size of the FFT context structure and temporary work buffer, use the `ippiFFTGetSize` function.

The `pMemInit` parameter can be `NULL` only if the work buffer is not used. After initialization is done, you can free the temporary work buffer.

The `ippiFFTFwd` and `ippiFFTInv` functions called with the pointer to the initialized `pFFTSpec` structure, compute the fast Fourier transform with the following characteristics:

- length \(N=2^{\text{orderX}}\) in x-direction by \(M=2^{\text{orderY}}\) in y-direction
- results normalization mode as set by `flag` (see Table "Normalization Factors for Fourier Transform Results")
- computation algorithm indicated by `hint`.

The suffix after the function name indicates the type of the context structure to be initialized: `ippiFFTInit_C` is for the complex FFT context structure and `ippiFFTInit_R` is for the real FFT context structure.

**Return Values**

- **ippStsNoErr**
  Indicates no error.

- **ippStsNullPtrErr**
  Indicates an error when one of the specified pointers is `NULL`.

- **ippStsFftOrderErr**
  Indicates an error condition when the FFT order value is illegal.

- **ippStsFftFlagErr**
  Indicates an error condition when the `flag` value is illegal.
### Example

The code example below demonstrates how to use the `ippiFFTGetSize` and `ippiFFTInit` functions.

```cpp
/// get sizes for required buffers
ippiFFTGetSize_R_32f( orderX, orderY, IPP_FFT_DIV_INV_BY_N, ippAlgHintNone, &sizeSpec, &sizeInit, &sizeBuffer );

/// allocate memory for required buffers
pMemSpec = (IppiFFTSpec_R_32f*) ippMalloc ( sizeSpec );
if ( sizeInit > 0 )
{
    pMemInit = ippMalloc ( sizeInit );
}
if ( sizeBuffer > 0 )
{
    pMemBuffer = ippMalloc ( sizeBuffer );
}

/// initialize FFT specification structure
ippiFFTInit_R_32f( orderX, orderY, IPP_FFT_DIV_INV_BY_N, ippAlgHintNone, pMemSpec, pMemInit );

/// free initialization buffer
if ( sizeInit > 0 )
{
    ippFree( pMemInit );
}

/// perform forward FFT to put source data to frequency domain
ippiFFTFwd_RToPack_32f_C1R( pSrc, srcStep, pDst, dstStep, pMemSpec, pMemBuffer );

/// ...

/// free buffers
if ( sizeBuffer > 0 )
{
    ippFree( pMemBuffer );
}

ippiFree( pMemSpec );
```

### See Also

- **FFTGetSize**  Computes the size of the FFT context structure and the size of the work buffer.
- **FFTInv**  Applies an inverse FFT to complex source data and stores results in a destination image.
- **FFTFwd**  Applies forward Fast Fourier Transform to an image.

### FFTFwd

*Applies forward Fast Fourier Transform to an image.*
Syntax

Case 1: Not-in-place operation on floating-point data

IppStatus ippiFFTFwd_RToPack_<mod> (const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, const IppiFFTSpec_R_32f* pFFTSpec, Ipp8u* pBuffer);

Supported values for mod:

32f_C1R
32f_C3R
32f_C4R
32f_AC4R

Case 2: Not-in-place operation on complex data

IppStatus ippiFFTFwd_CToC_32fc_C1R(const Ipp32fc* pSrc, int srcStep, Ipp32fc* pDst, int dstStep, const IppiFFTSpec_C_32fc* pFFTSpec, Ipp8u* pBuffer);

Case 3: In-place operation on floating-point data

IppStatus ippiFFTFwd_RToPack_<mod>(Ipp32f* pSrcDst, int srcDstStep, const IppiFFTSpec_R_32f* pFFTSpec, Ipp8u* pBuffer);

Supported values for mod:

32f_C1IR
32f_C3IR
32f_C4IR
32f_AC4IR

Case 4: In-place operation on complex data

IppStatus ippiFFTFwd_CToC_32fc_C1IR(Ipp32fc* pSrcDst, int srcDstStep, const IppiFFTSpec_C_32fc* pFFTSpec, Ipp8u* pBuffer);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc  
Pointer to the source image ROI.

srcStep  
Distance in bytes between starts of consecutive lines in the source image.

pDst  
Pointer to the destination image ROI.

dstStep  
Distance in bytes between starts of consecutive lines in the destination image.
Description
This function operates with ROI.

This function performs a forward FFT on each channel of the source image ROI \( pSrc \) (\( pSrcDst \) for in-place flavors) and writes the Fourier coefficients into the corresponding channel of the destination buffer \( pDst \) (\( pSrcDst \) for in-place flavors). The size of ROI is \( N \times M \), it is specified by the parameters \( \text{orderX}, \text{orderY} \).

The function flavor \( \text{ippiFFTFwd_RToPack} \) that operates on images with real data takes advantage of the symmetry property and stores the output data in RCPack2D format. It supports processing of the 1-, 3-, and 4-channel images. Note that the functions with \( \text{AC4} \) descriptor do not process alpha channel.

The function flavor \( \text{ippiFFTFwd_CToC} \) that operates on images with complex data does not perform any packing of the transform results as no symmetry with respect to frequency domain data is observed in this case. Memory layout of images with complex data follows the same conventions as for real images provided that each pixel value consists of two numbers: imaginary and real part.

Before using the forward FFT functions, you need to compute the size of the work buffer by \( \text{ippiFFTGetSize} \) and initialize the context structure by the \( \text{ippiFFTInit} \) function. The forward FFT functions use the \( pFFTSpec \) context structure to set the mode of calculations and retrieve support data.

Return Values

- \( \text{ippiStsNoErr} \): Indicates no error. Any other value indicates an error or a warning.
- \( \text{ippiStsNullPtrErr} \): Indicates an error condition if \( pSrc, pDst, \) or \( pFFTSpec \) pointer is NULL.
- \( \text{ippiStsStepErr} \): Indicates an error condition if \( srcStep \) or \( dstStep \) value is zero or negative.
- \( \text{ippiStsContextMatchErr} \): Indicates an error condition if a pointer to an invalid \( pFFTSpec \) structure is passed.
- \( \text{ippiStsMemAllocErr} \): Indicates an error condition if memory allocation fails.

Example
To better understand usage of these functions, refer to the \( \text{FFTFwd_CToC.c} \) and \( \text{FFTFwd_RToPack.c} \) examples in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples:

See Also
Regions of Interest in Intel IPP
\( \text{FFTGetSize} \) Computes the size of the FFT context structure and the size of the work buffer.
\( \text{FFTInit} \) Initializes the context structure for the image FFT functions.
**FFTInv**

Applies an inverse FFT to complex source data and stores results in a destination image.

**Syntax**

**Case 1: Not-in-place operation on floating-point data**

IppStatus ippiFFTInv_PackToR_<mod>(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, const IppiFFTSpec_R_32f* pFFTSpec, Ipp8u* pBuffer);

Supported values for mod:

- 32f_C1R
- 32f_C3R
- 32f_C4R
- 32f_AC4R

**Case 2: Not-in-place operation on complex data**

IppStatus ippiFFTInv_CToC_32fc_C1R(const Ipp32fc* pSrc, int srcStep, Ipp32fc* pDst, int dstStep, const IppiFFTSpec_C_32fc* pFFTSpec, Ipp8u* pBuffer);

**Case 3: In-place operation on floating-point data**

IppStatus ippiFFTInv_PackToR_<mod>(Ipp32f* pSrcDst, int srcDstStep, const IppiFFTSpec_R_32f* pFFTSpec, Ipp8u* pBuffer);

Supported values for mod:

- 32f_C1IR
- 32f_C3IR
- 32f_C4IR
- 32f_AC4IR

**Case 4: In-place operation on complex data**

IppStatus ippiFFTInv_CToC_32fc_C1IR(Ipp32fc* pSrcDst, int srcDstStep, const IppiFFTSpec_C_32fc* pFFTSpec, Ipp8u* pBuffer);

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **pSrcDst**: Pointer to the source and destination image ROI for the in-place operation.
- **srcDstStep**: Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.
- **pFFTSpec**: Pointer to the previously initialized FFT context structure.
- **pBuffer**: Pointer to the external work buffer.

Description

This function operates with ROI.

This function performs an inverse FFT on each channel of the source image `pSrc` (pSrcDst for in-place flavors) and writes the restored image data into the corresponding channel of the destination image buffer `pDst` (pSrcDst for in-place flavors). The size of ROI is $N \times M$, it is specified by the parameters `orderX`, `orderY`.

For the `ippiFFTInv_PackToR` function flavor, the input buffer must contain data in RCPack2D format.

Before using the inverse FFT functions, you need to compute the size of the work buffer by `ippiFFTGetSize` and initialize the context structure by the `ippiFFTInit` function. The inverse FFT functions use the `pFFTSpec` context structure to set the mode of calculations and retrieve support data.

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if `pSrc`, `pDst`, or `pFFTSpec` pointer is NULL.
- **ippStsStepErr**: Indicates an error condition if `srcStep` or `dstStep` value is zero or negative.
- **ippStsContextMatchErr**: Indicates an error condition if a pointer to an invalid `pFFTSpec` structure is passed.
- **ippStsMemAllocErr**: Indicates an error condition if memory allocation fails.

Example

To better understand usage of these functions, refer to the `FFTInv_CToC.c` and `FFTInv_RToPack.c` examples in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

See Also

- Regions of Interest in Intel IPP
- `FFTGetSize` Computes the size of the FFT context structure and the size of the work buffer.
- `FFTInit` Initializes the context structure for the image FFT functions.
DFTGetSize

Computes the size of the FFT context structure and the size of the work buffer.

Syntax

IppStatus ippiDFTGetSize_R_32f (IppSize roiSize, int flag, IppHintAlgorithm hint, int* pSizeSpec, int* pSizeInit, int* pSizeBuf);

IppStatus ippiDFTGetSize_C_32fc (IppSize roiSize, int flag, IppHintAlgorithm hint, int* pSizeSpec, int* pSizeInit, int* pSizeBuf);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

roiSize
Size of the source and destination ROI in pixels.

flag
Flag to choose the option for results normalization. For more information, see Table "Normalization Factors for Fourier Transform Results"

hint
This parameter is deprecated. Set the value to ippAlgHintNone.

pSizeSpec
Pointer to the size of the DFT context structure.

pSizeInit
Pointer to the size of the buffer for the DFT initialization function.

pSizeBuf
Pointer to the size of the DFT external work buffer.

Description

This function computes the following:

- Size of the DFT context structure. The result in bytes is stored in the pSpecSize parameter.
- Size of the work buffer for theippiDFTInit functions. The result, in bytes, is stored in the pSizeInit parameter.
- Size of the work buffer for theippiDFTFwd andippiDFTInv functions. The result, in bytes, is stored in the pSizeBuf parameter.

The suffix after the function name indicates the flavors of the DFT functions:ippiDFTGetSize_C is for complex flavors andippiDFTGetSize_R is for real flavors.

Return Values

ippStsNoErr
Indicates no error.

ippStsNullPtrErr
Indicates an error when one of the specified pointers is NULL.

ippStsFftFlagErr
Indicates an error condition when the flag value is illegal.
Indicates an error when the amount of memory needed to compute the DFT for points in the ROI of size roiSize exceeds the limit.

Indicates an error condition when the roiSize has a field with a zero or negative value.

**See Also**

**DFTInit**  Initializes the context structure for the image DFT functions.

### DFTInit

*Initializes the context structure for the image DFT functions.*

#### Syntax

```c
IppStatus ippiDFTInit_R_32f (IppiSize roiSize, int flag, IppHintAlgorithm hint,
IppiDFTSpec_R_32f* pDFTSpec, Ipp8u* pMemInit);
IppStatus ippiDFTInit_C_32fc (IppiSize roiSize, int flag, IppHintAlgorithm hint,
IppiDFTSpec_C_32fc* pDFTSpec, Ipp8u* pMemInit);
```

#### Include Files

`ippi.h`

#### Domain Dependencies

**Headers:**  `ippcore.h`, `ippvm.h`, `ipps.h`

**Libraries:**  `ippcore.lib`, `ippvm.lib`, `ipps.lib`

#### Parameters

- **roiSize**  
  Size of the source and destination ROI in pixels.

- **flag**  
  Flag to choose the option for results normalization.

- **hint**  
  This parameter is deprecated. Set the value to `ippAlgHintNone`.

- **pDFTSpec**  
  Pointer to the DFT context structure.

- **pMemInit**  
  Pointer to the temporary work buffer.

#### Description

This function initializes the `pDFTSpec` context structure needed to compute the forward and inverse DFT of a two-dimensional image data.

Before calling this function, you need to allocate memory for the FFT context structure and temporary work buffer (if it is required). To compute the size of the FFT context structure and temporary work buffer, use the `ippiDFTGetSize` function.

The `pMemInit` parameter can be `NULL` only if the work buffer is not used. After initialization is done, you can free the temporary work buffer.

The `ippiDFTFwd` and `ippiDFTInv` functions called with the pointer to the initialized `pDFTSpec` structure compute the discrete Fourier transform with the following characteristics:

- **ROI of the roiSize size**
- **results normalization mode set by flag** (see Table “Normalization Factors for Fourier Transform Results”)

---

**ippStsFftOrderErr**  
Indicates an error when the amount of memory needed to compute the DFT for points in the ROI of size roiSize exceeds the limit.

**ippStsSizeErr**  
Indicates an error condition when the roiSize has a field with a zero or negative value.
• computation algorithm indicated by hint.

The suffix after the function name indicates the type of the context structure to be initialized: ippiDFTInit_C is for the complex DFT context structure and ippiDFTInit_R is for the real DFT context structure.

**Return Values**

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error when one of the specified pointers is NULL.
- ippStsFftFlagErr: Indicates an error condition when the flag value is illegal.
- ippStsFftOrderErr: Indicates an error when the amount of memory needed to compute the DFT for points in the ROI of size roiSize exceeds the limit.
- ippStsSizeErr: Indicates an error condition when the roiSize has a field with a zero or negative value.

**Example**

The code example below demonstrates how to use the ippiDFTGetSize and ippiDFTInit functions.

```c
/// get sizes for required buffers
ippiDFTGetSize_R_32f( roiSize, IPP_FFT_DIV_INV_BY_N, ippAlgHintNone, &sizeSpec, &sizeInit, &sizeBuffer );

/// allocate memory for required buffers
pMemSpec = (IppiDFTSpec_R_32f*) ippMalloc ( sizeSpec );

if ( sizeInit > 0 )
{
    pMemInit = ippMalloc ( sizeInit );
}

if ( sizeBuffer > 0 )
{
    pMemBuffer = ippMalloc ( sizeBuffer );
}

/// initialize DFT specification structure
ippiDFTInit_R_32f( roiSize, IPP_FFT_DIV_INV_BY_N, ippAlgHintNone, pMemSpec, pMemInit );

/// free initialization buffer
if ( sizeInit > 0 )
{
    ippFree( pMemInit );
}

/// perform forward DFT to put source data to frequency domain
ippiDFTFwd_RToPack_32f_C1R( pSrc, srcStep, pDst, dstStep, pMemSpec, pMemBuffer );

/// ...

/// free buffers
if ( sizeBuffer > 0 )
{
    ippFree( pMemBuffer );
}
```
See Also
Regions of Interest in Intel IPP
DFTGetSize Computes the size of the FFT context structure and the size of the work buffer.
DFTFwd Applies forward discrete Fourier transform to an image.
DFTInv Applies an inverse DFT to complex source data and stores results in a destination image.

DFTFwd
Applies forward discrete Fourier transform to an image.

Syntax
Case 1: Not-in-place operation on floating-point data
IppStatus ippiDFTFwd_RToPack_<mod>(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, const IppiDFTSpec_R_32f* pDFTSpec, Ipp8u* pBuffer);

Supported values for mod:

32f_C1R
32f_C3R
32f_C4R
32f_AC4R

Case 2: Not-in-place operation on complex data
IppStatus ippiDFTFwd_CToC_32fc_C1R(const Ipp32fc* pSrc, int srcStep, Ipp32fc* pDst, int dstStep, const IppiDFTSpec_C_32fc* pDFTSpec, Ipp8u* pBuffer);

Case 3: In-place operation on floating-point data
IppStatus ippiDFTFwd_RToPack_<mod>(Ipp32f* pSrcDst, int srcDstStep, const IppiDFTSpec_R_32f* pDFTSpec, Ipp8u* pBuffer);

Supported values for mod:

32f_C1IR
32f_C3IR
32f_C4IR
32f_AC4IR

Case 4: In-place operation on complex data
IppStatus ippiDFTFwd_CToC_32fc_C1IR(Ipp32fc* pSrcDst, int srcDstStep, const IppiDFTSpec_C_32fc* pDFTSpec, Ipp8u* pBuffer);

Include Files
ippi.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **pSrcDst**: Pointer to the source and destination image ROI for the in-place operation.
- **srcDstStep**: Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.
- **pDFTSpec**: Pointer to the previously initialized DFT context structure.
- **pBuffer**: Pointer to the external work buffer.

Description

This function operates with ROI. This function performs a forward DFT on each channel of the source image ROI \( pSrc (pSrcDst \text{ for in-place flavors}) \) and writes the Fourier coefficients into the corresponding channel of the destination buffer \( pDst (pSrcDst \text{ for in-place flavors}) \).

The function flavor ippiDFTFwd_RToPack that operates on images with real data takes advantage of the symmetry property and stores the output data in RCPack2D format. It supports processing of the 1-, 3-, and 4-channel images. Note that the functions with AC4 descriptor do not process alpha channel.

The function flavor ippiDFTFwd_CToC that operates on images with complex data performs no packing of the transform results as no symmetry with respect to frequency domain data is observed in this case. Memory layout of images with complex data follows the same conventions as for real images provided that each pixel value consists of two numbers: imaginary and real part.

Before using the forward DFT functions, you need to compute the size of the work buffer by ippiDFTGetSize and initialize the context structure by the ippiDFTInit function. The forward DFT functions use the pDFTSpec context structure to set the mode of calculations and retrieve support data.

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if \( pSrc, pDst, \text{ or } pDFTSpec \) pointer is NULL.
- **ippStsStepErr**: Indicates an error condition if \( srcStep \) or \( dstStep \) value is zero or negative.
- **ippStsContextMatchErr**: Indicates an error condition if a pointer to an invalid \( pDFTSpec \) structure is passed.
- **ippStsMemAllocErr**: Indicates an error condition if memory allocation fails.
See Also
Regions of Interest in Intel IPP
DFTGetSize  Computes the size of the FFT context structure and the size of the work buffer.
DFTInit  Initializes the context structure for the image DFT functions.

DFTInv
Applies an inverse DFT to complex source data and stores results in a destination image.

Syntax
Case 1: Not-in-place operation on floating-point data
IppStatus ippDFTInv_PackToR_<mod>(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, const IppiDFTSpec_R_32f* pDFTSpec, Ipp8u* pBuffer);
Supported values for mod:

32f_C1R
32f_C3R
32f_C4R
32f_AC4R

Case 2: Not-in-place operation on complex data
IppStatus ippDFTInv_CToC_32fc_C1R(const Ipp32fc* pSrc, int srcStep, Ipp32fc* pDst, int dstStep, const IppiDFTSpec_C_32fc* pDFTSpec, Ipp8u* pBuffer);

Case 3: In-place operation on floating-point data
IppStatus ippDFTInv_PackToR_<mod>(Ipp32f* pSrcDst, int srcDstStep, const IppiDFTSpec_R_32f* pDFTSpec, Ipp8u* pBuffer);
Supported values for mod:

32f_C1IR
32f_C3IR
32f_C4IR
32f_AC4IR

Case 5: In-place operation on complex data
IppStatus ippDFTInv_CToC_32fc_C1IR(Ipp32fc* pSrcDst, int srcDstStep, const IppiDFTSpec_C_32fc* pDFTSpec, Ipp8u* pBuffer);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **pSrcDst**: Pointer to the source and destination image ROI for the in-place operation.
- **srcDstStep**: Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.
- **pDFTSpec**: Pointer to the previously initialized DFT context structure.
- **pBuffer**: Pointer to the external work buffer.

**Description**

This function operates with ROI.

This function performs an inverse DFT on each channel of the input buffer *pSrc* (*pSrcDst* for in-place flavors) and writes the restored image data into the corresponding channel of the output image buffer *pDst* (*pSrcDst* for in-place flavors).

For function flavor ippiDFTInv_PackToR, the input buffer must contain data in RCPack2D format.

Before using the inverse DFT functions, you need to compute the size of the work buffer by ippiDFTGetSize and initialize the context structure by the ippiDFTInit function. The inverse DFT functions use the *pDFTSpec* context structure to set the mode of calculations and retrieve support data.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if *pSrc*, *pDst*, or *pDFTSpec* pointer is NULL.
- **ippStsStepErr**: Indicates an error condition if *srcStep* or *dstStep* value is zero or negative.
- **ippStsContextMatchErr**: Indicates an error condition if a pointer to an invalid *pDFTSpec* structure is passed.
- **ippStsMemAllocErr**: Indicates an error condition if memory allocation fails.

**See Also**

- **Regions of Interest in Intel IPP**
- **DFTGetSize**: Computes the size of the FFT context structure and the size of the work buffer.
- **DFTInit**: Initializes the context structure for the image DFT functions.

**MulPack**

*Multiplies two source images in packed format.*
**Syntax**

IppStatus ippiMulPack_<mod>(const Ipp32f* pSrc1, int src1Step, const Ipp32f* pSrc2, int src2Step, Ipp32f* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:

- 32f_C1R
- 32f_C3R
- 32f_C4R
- 32f_AC4R

IppStatus ippiMulPack_<mod>(const Ipp32f* pSrc, int srcStep, Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

- 32f_C1IR
- 32f_C3IR
- 32f_C4IR
- 32f_AC4IR

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **pSrc1, pSrc2**
  - Pointer to the ROI in the source images.

- **src1Step, src2Step**
  - Distance in bytes between starts of consecutive lines in the source images.

- **pDst**
  - Pointer to the destination image ROI.

- **dstStep**
  - Distance in bytes between starts of consecutive lines in the destination image.

- **pSrc**
  - Pointer to the first source image ROI for the in-place operation.

- **srcStep**
  - Distance in bytes between starts of consecutive lines in the first source image for the in-place operation.

- **pSrcDst**
  - Pointer to the second source and destination image ROI for the in-place operation.

- **srcDstStep**
  - Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.

- **roiSize**
  - Size of the source and destination ROI in pixels.
scaleFactor

Scale factor (see Integer Result Scaling).

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function multiplies corresponding pixel values of two source images, \(A\) and \(B\) represented in RCPack2D format and stores the result into the destination image \(C\) in packed format also. The multiplying is performed according to the following formulas:
\[
\begin{align*}
\text{Re}C &= \text{Re}A \times \text{Re}B - \text{Im}A \times \text{Im}B; \\
\text{Im}C &= \text{Im}A \times \text{Re}B + \text{Im}B \times \text{Re}A.
\end{align*}
\]
Not-in-place flavors multiply pixel values of ROI in the source images \(pSrc1\) and \(pSrc2\), and store result in the \(pDst\).
In-place flavors multiply pixel values of ROI in the source images \(pSrc\) and \(pSrcDst\), and store result in the \(pSrcDst\).
This function can be used in image filtering operations that include FFT transforms.

Example
To better understand usage of this function, refer to the MulPack.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

Return Values

<table>
<thead>
<tr>
<th>Status Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error or a warning.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error condition if any of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error condition if (roiSize) has a field with zero or negative value.</td>
</tr>
<tr>
<td>ippStsStepErr</td>
<td>Indicates an error condition if any of the specified buffer step values is zero or negative.</td>
</tr>
</tbody>
</table>

MulPackConj

Multiplication of a source image by the complex conjugate image with data in packed format and stores the result in the destination buffer in the packed format.

Syntax

Case 1: Not-in-place operation

IppStatus ippiMulPackConj_<mod>(const Ipp32f* \(pSrc1\), int \(src1\)Step, const Ipp32f* \(pSrc2\), int \(src2\)Step, Ipp32f* \(pDst\), int \(dst\)Step, IppiSize \(roi\)Size);

Supported values for \(mod\):

- 32f_C1R
- 32f_C3R
- 32f_C4R
32f_AC4R

**Case 2: In-place operation**

IppStatus ippiMulPackConj_mod(const Ipp32f* pSrc, int srcStep, Ipp32f* pSrcDst, int srcDstStep, IppiSize roiSize);

Supported values for mod:

- 32f_C1IR
- 32f_C3IR
- 32f_C4IR
- 32f_AC4IR

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- `pSrc1, pSrc2` – Pointer to the ROI in the source images.
- `src1Step, src2Step` – Distance in bytes between starts of consecutive lines in the source images.
- `pDst` – Pointer to the destination image ROI.
- `dstStep` – Distance in bytes between starts of consecutive lines in the destination image.
- `pSrc` – Pointer to the first source image ROI for the in-place operation.
- `srcStep` – Distance in bytes between starts of consecutive lines in the first source image for the in-place operation.
- `pSrcDst` – Pointer to the second source and destination image ROI for the in-place operation.
- `srcDstStep` – Distance in bytes between starts of consecutive lines in the source and destination image for the in-place operation.
- `roiSize` – Size of the source and destination ROI in pixels.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function multiplies pixel values of the source image \( A \) by the corresponding pixel values of the complex conjugate image \( A^* \), represented in RCPack2D format. The result of the operation is written into the destination buffer in packed format also.

Not-in-place flavors multiply pixel values of ROI in the source images `pSrc1` and `pSrc2`, and store result in the `pDst`.
In-place flavors multiply pixel values of ROI in the source images \( p_{Src} \) and \( p_{SrcDst} \), and store result in the \( p_{SrcDst} \).

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if any of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if \( roiSize \) has a field with zero or negative value.
- **ippStsStepErr**: Indicates an error condition if any of the specified buffer step values is zero or negative.

**Magnitude**

*Computes magnitude of elements of a complex data image.*

**Syntax**

\[
\text{IppStatus ippiMagnitude}_{<\text{mod}>}(\text{const Ipp}<\text{srcDatatype}>^* p_{Src}, \text{int} \ src\text{Step}, \text{Ipp}<\text{dstDatatype}>^* p_{Dst}, \text{int} \ dst\text{Step}, \text{IppiSize} \ roi\text{Size});
\]

Supported values for \( \text{mod} \):

- 32fc32f_C1R 32fc32f_C3R

**Include Files**

ippi.h

**Domain Dependencies**

**Headers**: ippcore.h, ippvm.h, ipps.h

**Libraries**: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- \( p_{Src} \): Pointer to the source image ROI.
- \( src\text{Step} \): Distance in bytes between starts of consecutive lines in the source image.
- \( p_{Dst} \): Pointer to the destination image ROI.
- \( dst\text{Step} \): Distance in bytes between starts of consecutive lines in the destination image.
- \( roi\text{Size} \): Size of the source and destination ROI in pixels.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function computes magnitude of elements of the source image \( p_{Src} \) given in complex data format, and stores results in the destination image \( p_{Dst} \).
Return Values

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error or a warning.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error condition if pSrc or pDst pointer is NULL.</td>
</tr>
<tr>
<td>ippStsStepErr</td>
<td>Indicates an error condition if srcStep or dstStep value is zero or negative.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error condition if width or height of images is less than or equal to zero.</td>
</tr>
</tbody>
</table>

MagnitudePackGetBufferSize

*Computes the size of the work buffer for the ippiMagnitudePack function.*

Syntax

```c
IppStatus ippiMagnitudePackGetBufferSize_32f (int numChannels, IppiSize dstRoiSize, int* pSize);
```

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **numChannels**
  - Number of channels in the image. Possible values are 1 and 3.
- **dstRoiSize**
  - Size, in pixels, of the destination image ROI.
- **pSize**
  - Pointer to the computed size of the external work buffer, in bytes.

Description

The `ippiMagnitudePackGetBufferSize` function computes the size, in bytes, of the external work buffer needed for the `ippiMagnitudePack` function. The result is stored in the `pSize` parameter.

Return Values

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error when <code>pSize</code> is NULL.</td>
</tr>
<tr>
<td>ippStsStepErr</td>
<td>Indicates an error when <code>dstRoiSize</code> has a field with a value less than 1.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error when <code>numChannels</code> has an illegal value.</td>
</tr>
</tbody>
</table>

See Also

MagnitudePack MODIFIED API. Computes magnitude of elements of an image in packed format.
MagnitudePack
MODIFIED API. Computes magnitude of elements of an image in packed format.

Syntax
IppStatus ippiMagnitudePack_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppSize dstRoiSize, Ipp8u* pBuffer);

Supported values for mod:
32f_C1R  32f_C3R

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pSrc
Pointer to the source image ROI.
srcStep
Distance in bytes between starts of consecutive lines in the source image.
pDst
Pointer to the destination image ROI.
dstStep
Distance in bytes between starts of consecutive lines in the destination image.
dstRoiSize
Size of the destination ROI in pixels.
pBuffer
Pointer to the work buffer. To compute the size of the buffer, use the ippiMagnitudePackGetBufferSize function.

Description
Important The API of this function has been modified in Intel IPP 9.0 release.

This function operates with ROI (see Regions of Interest in Intel IPP).
This function computes magnitude of elements of the source image pSrc given in RCPack2D format and stores results in the destination image pDst.

Return Values
ippStsNoErr
Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr
Indicates an error when pSrc or pDst pointer is NULL.
ippStsStepErr
Indicates an error when srcStep or dstStep value is zero or negative.
Indicates an error when width or height of images is less than, or equal to zero.

See Also
MagnitudePackGetBufferSize Computes the size of the work buffer for the ippiMagnitudePack function.
Regions of Interest in Intel IPP
Real - Complex Packed (RCPack2D) Format

Phase
Computes the phase of elements of a complex data image.

Syntax
IppStatus ippiPhase_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppiSize roiSize);

Supported values for mod:
32fc32f_C1R 32fc32f_C3R

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc Pointer to the source image ROI.
srcStep Distance in bytes between starts of consecutive lines in the source image.
pDst Pointer to the destination image ROI.
dstStep Distance in bytes between starts of consecutive lines in the destination image.
roiSize Size of the source and destination ROI in pixels.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function computes the phase in radians of elements of a source image pSrc given in complex data format, and stores results in the destination image pDst.

Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error condition if pSrc or pDst pointer is NULL.
ippStsStepErr Indicates an error condition if srcStep or dstStep value is zero or negative.
ippStsSizeErr Indicates an error condition if width or height of images is less than or equal to zero.

PhasePackGetSize
Computes the size of the work buffer for the ippiPhasePack function.

Syntax
IppStatus ippiPhasePackGetSize_32f (int numChannels, IppiSize dstRoiSize, int* pSize);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
numChannels Number of channels in the image. Possible values are 1 and 3.
dstRoiSize Size, in pixels, of the destination image ROI.
pSize Pointer to the computed size of the external work buffer, in bytes.

Description
The ippiPhasePackGetSize function computes the size, in bytes, of the external work buffer needed for the ippiPhasePack function. The result is stored in the pSize parameter.

Return Values
ippStsNoErr Indicates no error.
ippStsNullPtrErr Indicates an error when pSize is NULL.
ippStsSizeErr Indicates an error when dstRoiSize has a field with a value less than 1.
ippStsNumChannelsErr Indicates an error when numChannels has an illegal value.

See Also
PhasePack MODIFIED API. Computes the phase of elements of an image in packed format.

PhasePack
MODIFIED API. Computes the phase of elements of an image in packed format.
Syntax

IppStatus ippiPhasePack_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppSize dstRoiSize, Ipp8u* pBuffer);

Supported values for mod:

32f_C1R 32f_C3R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc Pointer to the source image ROI.
srcStep Distance in bytes between starts of consecutive lines in the source image.
pDst Pointer to the destination image ROI.
dstStep Distance in bytes between starts of consecutive lines in the destination image.
dstRoiSize Size of the destination ROI in pixels.
pBuffer Pointer to the work buffer. To compute the size of the buffer, use the PhasePackGetBufferSize function.

Description

Important The API of this function has been modified in Intel IPP 9.0 release.

This function operates with ROI (see Regions of Interest in Intel IPP).
This function computes the phase of elements of a source image pSrc given in RCPack2D format and stores the results in the destination image pDst.

Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error when pSrc or pDst pointer is NULL.
ippStsStepErr Indicates an error when srcStep or dstStep value is zero or negative.
ippStsSizeErr Indicates an error when width or height of images is less than, or equal to zero.

See Also

PhasePackGetBufferSize Computes the size of the work buffer for the ippiPhasePack function.
Regions of Interest in Intel IPP
Real - Complex Packed (RCPack2D) Format
**PolarToCart**  
*Converting an image in the polar coordinate form to Cartesian coordinate form.*

**Syntax**

```c
IppStatus ippiPolarToCart_<mod>(const Ipp32f* pSrcMagn, const Ipp32f* pSrcPhase, int srcStep, IppiSize roiSize, Ipp32fc* pDst, int dstStep);
```

**Supported values for mod:**

- 32fc_C1R
- 32fc_C3R

**Include Files**

ippi.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- `pSrcMagn`: Pointer to the buffer containing magnitudes of the source image.
- `pSrcPhase`: Pointer to the buffer containing phase values of the source image.
- `srcStep`: Distance in bytes between starts of consecutive lines in the source buffers.
- `roiSize`: Size of the source and destination image ROI.
- `pDst`: Pointer to the destination image ROI.
- `dstStep`: Distance in bytes between starts of consecutive lines in the destination image buffer.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the polar coordinate of the source image stored in the arrays of magnitudes `pSrcMagn` and phase values `pSrcPhase` to the destination image `pDst` in complex-data format (in Cartesian coordinate form).

**Return Values**

- `ippStsNoErr`: Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr`: Indicates an error condition if one of the specified pointers is NULL.
- `ippStsStepErr`: Indicates an error condition if `srcStep` or `dstStep` value is zero or negative.
- `ippStsSizeErr`: Indicates an error condition if `srcSize` has a field with value less than 1.
Example
The code example below shows how to use the function ippiPolarToCart_32fc_C1R.

```c
void func_polartocart()
{
    Ipp32f pSrcMagn[2*2] = {1.0, 0.0, 2.1, 3.2};
    Ipp32f pSrcPhase[2*2] = {0.0, 2.0, 1.6,-1.0};
    Ipp32fc pDst[2*2] = {0};
    int srcStep = 2*sizeof(Ipp32f);
    int dstStep = 2*sizeof(Ipp32fc);
    IppiSize roiSize = {2, 2};

    ippiPolarToCart_32fc_C1R(pSrcMagn, pSrcPhase, srcStep, roiSize, pDst, dstStep);
}
```
Result: pDst -> (1.0, 0.0) (0.0, 0.0) (-0.1, 2.1) (1.7, -2.7)

PackToCplxExtend
Converts an image in packed format to a complex data image.

Syntax
ippiPackToCplxExtend_32f32fc_C1R(const Ipp32f* pSrc, IppiSize srcSize, int srcStep, Ipp32fc* pDst, int dstStep);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
- `pSrc`  
  Pointer to the source image ROI.
- `srcSize`  
  Size in pixels of the source image ROI.
- `srcStep`  
  Distance in bytes between starts of consecutive lines in the source buffer.
- `pDst`  
  Pointer to the destination image buffer.
- `dstStep`  
  Distance in bytes between starts of consecutive lines in the destination image buffer.
Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function converts the source image `pSrc` in RCPack2D format to complex data format and stores the results in `pDst`, which is a matrix with complete set of the Fourier coefficients. Note that if the `pSrc` in RCPack2D format is a real array of dimensions \((N \times M)\), then the `pDst` is a real array of dimensions \((2 \times N \times M)\). This should be taken into account when allocating memory for the function operation.

Return Values
ippStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  
Indicates an error condition if `pSrc` or `pDst` pointer is NULL.

ippStsStepErr  
Indicates an error condition if `srcStep` or `dstStep` value is zero or negative.

ippStsSizeErr  
Indicates an error condition if `srcSize` has field with zero or negative value.

CplxExtendToPack
Converts a complex data image to an image in packed format.

Syntax
IppStatus ippiCplxExtendToPack_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, IppiSize srcSize, Ipp<dstDatatype>* pDst, int dstStep);

Supported values for `mod`:

- 32fc32f_C1R
- 32fc32f_C3R

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- `pSrc`  
  Pointer to the source image ROI.

- `srcSize`  
  Size in pixels of the source image ROI.

- `srcStep`  
  Distance in bytes between starts of consecutive lines in the source buffer.

- `pDst`  
  Pointer to the destination image buffer.

- `dstStep`  
  Distance in bytes between starts of consecutive lines in the destination image buffer.
Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function converts the source image pSrc in complex data format to RCPack2D format and stores the results in pDst, which is a real array of dimensions (NxM). The pSrc is a matrix with complete set of the Fourier coefficients.

Return Values
ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error condition if pSrc or pDst pointer is NULL.
ippStsStepErr Indicates an error condition if srcStep or dstStep value is zero or negative.
ippStsSizeErr Indicates an error condition if srcSize has field with zero or negative value.

Windowing Functions
This section describes Intel IPP windowing functions used in image processing. A window is a mathematical function by which pixel values are multiplied to prepare an image for the subsequent analysis. This procedure is often called 'windowing'. In fact, a window function approaches zero towards the edges of the image avoiding strong distortions of spectral densities in the Fourier domain.
The Intel IPP provides two following types of window functions:
• Bartlett window function
• Hamming window function
These functions generate the window samples and applied them to the specified image. To obtain the window samples themselves, you should apply the desired function to the image with all pixel values set to 1.0. As the windowing operation is very time consuming, it may be useful if you want to apply the same window to the multiple images. In this case use one of the image multiplication functions (ippiMul) to multiply the pixel values of the image by the window samples.

WinBartlettGetBufferSize, WinBartlettSepGetBufferSize,
Compute the size of the work buffer for the ippiWinBartlett or ippiWinBartlettSep function.

Syntax
IppStatus ippiWinBartlettGetBufferSize (IppDataType dataType, IppiSize roiSize, int* pSize);
IppStatus ippiWinBartlettSepGetBufferSize (IppDataType dataType, IppiSize roiSize, int* pSize);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

datatype
Data type for the Bartlett window function. Possible values are:
ipp8u, ipp16u, or ipp32f.

roiSize
Size, in pixels, of the image ROI.

pSize
Pointer to the computed size of the external work buffer, in bytes.

Description
The ippiWinBartlettGetBufferSize and ippiWinBartlettSepGetBufferSize functions compute the size, in bytes, of the external work buffer needed for the ippiWinBartlett or ippiWinBartlettSep function. The result is stored in the pSize parameter.

Return Values

ippStsNoErr
Indicates no error.

ippStsNullPtrErr
Indicates an error when pSize is NULL.

ippStsSizeErr
Indicates an error when roiSize has a field with a value less than 3.

ippStsNumChannelsErr
Indicates an error when dataType has an illegal value.

See Also
WinBartlett, WinBartlettSep MODIFIED API. Apply Bartlett window function to the image.

WinBartlett, WinBartlettSep
MODIFIED API. Apply Bartlett window function to the image.

Syntax

Case 1: Not-in-place operation

IppStatus ippiWinBartlett_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, Ipp8u* pBuffer);

Supported values for mod:

8u_C1R 16u_C1R 32f_C1R

IppStatus ippiWinBartlettSep_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, Ipp8u* pBuffer);

Supported values for mod:

8u_C1R 16u_C1R 32f_C1R
Case 2: In-place operation

IppStatus ippiWinBartlett_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp8u* pBuffer);

Supported values for mod:

8u_C1IR 16u_C1IR 32f_C1IR

IppStatus ippiWinBartlettSep_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp8u* pBuffer);

Supported values for mod:

8u_C1IR 16u_C1IR 32f_C1IR

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc Pointer to the source image ROI.
srcStep Distance, in bytes, between the starting points of consecutive lines in the source image.

pDst Pointer to the destination image ROI.
dstStep Distance, in bytes, between the starting points of consecutive lines in the destination image.

pSrcDst Pointer to the source and destination image ROI for the in-place operation.
srcDstStep Distance, in bytes, between the starting points of consecutive lines in the source and destination image for the in-place operation.
roiSize Size of the source and destination ROI, in pixels.
pBuffer Pointer to the work buffer. To compute the size of the buffer, use the WinBartlettGetBufferSize WinBartlettSepGetBufferSize or WinBartlettGetBufferSize WinBartlettSepGetBufferSize function.

Description

These functions operate with ROI (see Regions of Interest in Intel IPP).

These functions compute the Bartlett (triangle) window samples, multiply pixel values of the source image pSrc (pSrcDst for in-place flavors) with these samples, and store results in the destination image pDst (pSrcDst for in-place flavors).

The Bartlett window function for one-dimensional case with $M$ elements is defined as follows:
The ippiWinBartlettSep flavor applies the window function successively to the rows and then to the columns of the image.

Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error or a warning.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error when pSrc or pDst pointer is NULL.</td>
</tr>
<tr>
<td>ippStsStepErr</td>
<td>Indicates an error when srcStep or dstStep value is zero or negative.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error when width or height of images is less than, or equal to zero.</td>
</tr>
</tbody>
</table>

See Also

WinBartlettGetBufferSize, WinBartlettSepGetBufferSize  Compute the size of the work buffer for the ippiWinBartlett or ippiWinBartlettSep function.

Regions of Interest in Intel IPP

WinHammingGetBufferSize, WinHammingSepGetBufferSize,
Compute the size of the work buffer for the ippiWinHamming or ippiWinHammingSep function.

Syntax

```c
IppStatus ippiWinHammingGetBufferSize (IppDataType dataType, IppiSize roiSize, int* pSize);
IppStatus ippiWinHammingSepGetBufferSize (IppDataType dataType, IppiSize roiSize, int* pSize);
```

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dataType</td>
<td>Data type for the Bartlett window function. Possible values are: ipp8u, ipp16u, or ipp32f.</td>
</tr>
<tr>
<td>roiSize</td>
<td>Size, in pixels, of the image ROI.</td>
</tr>
<tr>
<td>pSize</td>
<td>Pointer to the computed size of the external work buffer, in bytes.</td>
</tr>
</tbody>
</table>
Description

The `ippiWinHammingGetBufferSize` and `ippiWinHammingSepGetBufferSize` functions compute the size, in bytes, of the external work buffer needed for the `ippiWinHamming` or `ippiWinHammingSep` function. The result is stored in the `pSize` parameter.

Return Values

- `ippStsNoErr` Indicates no error.
- `ippStsNullPtrErr` Indicates an error when `pSize` is NULL.
- `ippStsSizeErr` Indicates an error when `roiSize` has a field with a value less than 3.
- `ippStsNumChannelsErr` Indicates an error when `dataType` has an illegal value.

See Also

`WinHamming`, `WinHammingSep` MODIFIED API. Apply Hamming window function to the image.

WinHamming, WinHammingSep

MODIFIED API. Apply Hamming window function to the image.

Syntax

Case 1: Not-in-place operation

```c
IppStatus ippiWinHamming_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, Ipp8u* pBuffer);
```

Supported values for `mod`:

- 8u_C1R
- 16u_C1R
- 32f_C1R

```c
IppStatus ippiWinHammingSep_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, Ipp8u* pBuffer);
```

Supported values for `mod`:

- 8u_C1R
- 16u_C1R
- 32f_C1R

Case 2: In-place operation

```c
IppStatus ippiWinHamming_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp8u* pBuffer);
```

Supported values for `mod`:

- 8u_C1IR
- 16u_C1IR
- 32f_C1IR

```c
IppStatus ippiWinHammingSep_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp8u* pBuffer);
```

Supported values for `mod`:

- 8u_C1IR
- 16u_C1IR
- 32f_C1IR
Include Files
ippi.h

Domain Dependencies
Headers: ippi.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

\textit{pSrc} \quad \text{Pointer to the source image ROI.}
\textit{srcStep} \quad \text{Distance, in bytes, between the starting points of consecutive}
\text{lines in the source image.}
\textit{pDst} \quad \text{Pointer to the destination image ROI.}
\textit{dstStep} \quad \text{Distance, in bytes, between the starting points of consecutive}
\text{lines in the destination image.}
\textit{pSrcDst} \quad \text{Pointer to the source and destination image ROI for the in-}
\text{place operation.}
\textit{srcDstStep} \quad \text{Distance, in bytes, between the starting points of consecutive}
\text{lines in the source and destination image for the in-place}
\text{operation.}
\textit{roiSize} \quad \text{Size of the source and destination ROI, in pixels.}
\textit{pBuffer} \quad \text{Pointer to the work buffer. To compute the size of the buffer,}
\text{use the \texttt{ippiWinHammingGetBufferSize} or}
\textit{ippiWinHammingSepGetBufferSize} function.

Description

These functions operate with ROI (see Regions of Interest in Intel IPP).
These functions compute the Hamming (triangle) window samples, multiply pixel values of the source image
\textit{pSrc} (\textit{pSrcDst} for in-place flavors) with these samples, and store results in the destination image \textit{pDst}
( \textit{pSrcDst} for in-place flavors).
The Hamming window function for one-dimensional case with \textit{M} elements is defined as follows:
\[ w_{\text{hamming}}(n) = 0.54 - 0.46 \cos \left( \frac{2\pi n}{len-1} \right) \]
The \texttt{ippiWinHammingSep} flavor applies the window function successively to the rows and then to the
columns of the image.

Return Values

\texttt{ippStsNoErr} \quad \text{Indicates no error. Any other value indicates an error or a}
\text{warning.}
\texttt{ippStsNullPtrErr} \quad \text{Indicates an error when \textit{pSrc} or \textit{pDst} pointer is NULL.}
\texttt{ippStsStepErr} \quad \text{Indicates an error when \textit{srcStep} or \textit{dstStep} value is zero or}
\text{negative.}
\texttt{ippStsSizeErr} \quad \text{Indicates an error when width or height of images is less than, or}
\text{equal to zero.}
See Also
WinHammingGetSize, WinHammingSepGetSize Compute the size of the work buffer for theippiWinHamming or ippiWinHammingSep function.

Regions of Interest in Intel IPP

Discrete Cosine Transforms

Discrete Cosine Transform (DCT) of a real 2D image yields output results that are also real, which eliminates the need to use packed format for storing the transformed data. However, forward and inverse DCT functionsippiDCTFwd andippiDCTInv need different context data structures to be initialized and filled in prior to their use. Consequently, the required workspace buffer size is different for these functions. In case of using an external buffer, its size must be determined by previously calling the respective support function. DCT functions that use context structures implement the modified computation algorithm proposed in [Rao90].

The DCT functionsippiDCT8x8Fwd andippiDCT8x8Inv working on a fixed 8x8 image buffer need no context data or external workspace buffers. FunctionsippiDCT8x8Inv meet IEEE-1180 standard requirements (see [IEEE]).

Intel IPP Discrete Cosine Transform functions working on a fixed 8x8 image buffer use Feig and Winograd algorithm ([Feig92]) modified for taking advantage of SIMD instructions. For details on algorithms used in DCT transforms and for more references, see [AP922].

<table>
<thead>
<tr>
<th>Optimization Notice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intel's compilers may or may not optimize to the same degree for non-Intel microprocessors for optimizations that are not unique to Intel microprocessors. These optimizations include SSE2, SSE3, and SSSE3 instruction sets and other optimizations. Intel does not guarantee the availability, functionality, or effectiveness of any optimization on microprocessors not manufactured by Intel. Microprocessor-dependent optimizations in this product are intended for use with Intel microprocessors. Certain optimizations not specific to Intel microarchitecture are reserved for Intel microprocessors. Please refer to the applicable product User and Reference Guides for more information regarding the specific instruction sets covered by this notice.</td>
</tr>
<tr>
<td>Notice revision #20110804</td>
</tr>
</tbody>
</table>

DCTFwdGetSize, DCTInvGetSize

Compute the size of the DCT context structure and the size of the required work buffers.

Syntax

IppStatusippiDCTFwdGetSize_32f(IppSize roiSize, int*pSizeSpec, int*pSizeInit, int*pSizeBuf);
IppStatusippiDCTInvGetSize_32f(IppSize roiSize, int*pSizeSpec, int*pSizeInit, int*pSizeBuf);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>roiSize</td>
<td>Size of the source and destination ROI, in pixels.</td>
</tr>
<tr>
<td>pSizeSpec</td>
<td>Pointer to the size of the DCT context structure.</td>
</tr>
<tr>
<td>pSizeInit</td>
<td>Pointer to the size of the buffer for the DCT initialization function.</td>
</tr>
<tr>
<td>pSizeBuf</td>
<td>Pointer to the size of the DCT external work buffer.</td>
</tr>
</tbody>
</table>

### Description

These functions compute the following:

1. Size of the DCT context structure. The result, in bytes, is stored in the `pSizeSpec` parameter.
2. Size of the work buffer for the `ippiDCTFwdInit` and `ippiDCTInvInit` functions. The result, in bytes, is stored in the `pSizeInit` parameter.
3. Size of the work buffer for the `ippiDCTFwd` and `ippiDCTInv` functions. The result, in bytes, is stored in the `pSizeBuf` parameter.

### Return Values

<table>
<thead>
<tr>
<th>Return</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error.</td>
</tr>
<tr>
<td>ippStsNullFtrErr</td>
<td>Indicates an error when one of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error when <code>roiSize</code> has a field with a zero or negative value.</td>
</tr>
</tbody>
</table>

### See Also

- **DCTFwdInit, DCTInvInit**: Initialize the context structure for the forward or inverse DCT operation.
- **DCTFwd**: Applies a forward discrete cosine transform to an image.
- **DCTInv**: Applies an inverse discrete cosine transform to an image.
Parameters

- **pDCTSpec**
  Pointer to the forward or inverse DCT context structure for initialization.

- **roiSize**
  Size of the source and destination ROI, in pixels.

- **pMemInit**
  Pointer to the temporary work buffer.

Description

These functions initialize the `pDCTSpec` context structure to apply the forward or inverse DCT to two-dimensional image data. The `ippiDCTFwd` and `ippiDCTInv` functions use the pointer to the initialized DCT context structure as an argument to compute the forward or inverse DCT for points in the ROI of size `roiSize`.

Return Values

- **ippStsNoErr**
  Indicates no error.

- **ippStsNullPtrErr**
  Indicates an error when one of the specified pointers is `NULL`.

- **ippStsSizeErr**
  Indicates an error when `roiSize` has a field with a zero or negative value.

See Also

- **DCTFwd**  Applies a forward discrete cosine transform to an image.
- **DCTInv**  Applies an inverse discrete cosine transform to an image.

DCTFwd

Apply a forward discrete cosine transform to an image.

Syntax

```c
IppStatus ippiDCTFwd_<mod> (const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, const IppiDCTFwdSpec_32f* pDCTSpec, Ipp8u* pBuffer);
```

Supported values for `mod`:

- 32f_C1R
- 32f_C3R
- 32f_C4R
- 32f_AC4R

Include Files

- ippi.h

Domain Dependencies

- Headers: ippcore.h, ippvm.h, ipps.h
- Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance, in bytes, between the starting points of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance, in bytes, between the starting points of consecutive lines in the destination image.
- **pDCTSpec**: Pointer to the previously initialized forward DCT context structure.
- **pBuffer**: Pointer to the external work buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP) of the size that is specified by the `ippiDFTInit` function.

This function performs a forward DCT on each channel of the source image `pSrc` and writes the result into the corresponding channel of the destination image buffer `pDst`. Note that the function flavor with AC4 descriptor does not process alpha channel. This function uses the previously initialized `pDCTSpec` context structure to set the mode of calculations and retrieve support data.

You can use this function with the external work buffer `pBuffer` to avoid memory allocation within the functions. Once the work buffer is allocated, it can be used for all following calls to the functions computing DCT. As internal allocation of memory is too expensive operation and depends on operating system and/or runtime libraries used - the use of an external buffer improves performance significantly, especially for the small size transforms.

Before using the forward DCT functions, you need to compute the size of the required buffers and the external work buffer using the `ippiDCTFwdGetSize` function.

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if `pSrc`, `pDst`, or `pDCTSpec` pointer is NULL.
- **ippStsStepErr**: Indicates an error condition if `srcStep` or `dstStep` value is zero or negative.
- **ippStsContextMatchErr**: Indicates an error condition if a pointer to an invalid `pDCTSpec` structure is passed.
- **ippStsMemAllocErr**: Indicates an error condition if memory allocation fails.

Example

The code example below demonstrates how to use the `ippiDCTFwdGetSize`, `ippiDCTFwdInit`, and `ippiDCTFwd` functions.

```c
void DCT_example( void )
{
    Ipp32f Src[8*8] = {
        0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0,
        0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0,
        0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0,
        0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0,
```

---

0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0,
0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0,
0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0,
0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0
};
Ipp32f Dst[8*8];
IppiSize roiSize = {8, 8};
int srcStep;
int dstStep;

int sizeSpec;
int sizeInit;
int sizeBuffer;

IppiDCTFwdSpec_32f *pMemSpec;
Ipp8u *pMemInit = 0;
Ipp8u *pMemBuffer = 0;

srcStep = dstStep = 8 * sizeof(Ipp32f);

/// get sizes for required buffers
ippiDCTFwdGetSize_32f( roiSize, &sizeSpec, &sizeInit, &sizeBuffer );

/// allocate memory for required buffers
pMemSpec = (IppiDCTFwdSpec_32f*) ippMalloc ( sizeSpec );
if ( sizeInit > 0 )
{
    pMemInit = (Ipp8u*) ippMalloc ( sizeInit );
}
if ( sizeBuffer > 0 )
{
    pMemBuffer = (Ipp8u*) ippMalloc ( sizeBuffer );
}

/// initialize DCT specification structure
ippiDCTFwdInit_32f( pMemSpec, roiSize, pMemInit );

/// free initialization buffer
if ( sizeInit > 0 )
{
    ippFree( pMemInit );
}

/// perform forward DCT
ippiDCTFwd_32f_C1R( Src, srcStep, Dst, dstStep, pMemSpec, pMemBuffer );

/// ...

/// free buffers
if ( sizeBuffer > 0 )
{
    ippFree( pMemBuffer );
}

ippFree( pMemSpec );
Result:

<table>
<thead>
<tr>
<th>Dst -&gt;</th>
<th>28.0</th>
<th>-18.2</th>
<th>0.0</th>
<th>-1.9</th>
<th>0.0</th>
<th>-0.57</th>
<th>0.0</th>
<th>-0.14</th>
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</tr>
</tbody>
</table>

**DCTInv**

*Applies an inverse discrete cosine transform to an image.*

**Syntax**

```c
IppStatus ippiDCTInv_<mod> (const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep,
const IppiDCTInvSpec_32f* pDCTSpec, Ipp8u* pBuffer);
```

Supported values for *mod*:

- `32f_C1R`
- `32f_C3R`
- `32f_C4R`
- `32f_AC4R`

**Include Files**

`ippi.h`

**Domain Dependencies**

*Headers:* `ippcore.h`, `ippvm.h`, `ipps.h`

*Libraries:* `ippcore.lib`, `ippvm.lib`, `ipps.lib`

**Parameters**

- `<pSrc>` Pointer to the source image ROI.
- `<srcStep>` Distance, in bytes, between the starting points of consecutive lines in the source image.
- `<pDst>` Pointer to the destination image ROI.
- `<dstStep>` Distance, in bytes, between the starting points of consecutive lines in the destination image.
- `<pDCTSpec>` Pointer to the previously initialized inverse DCT context structure.
- `<pBuffer>` Pointer to the external work buffer.

**Description**

This function operates with ROI (see *Regions of Interest in Intel IPP*) of the size that is specified by the `ippiDCTInvInit` function.
This function performs an inverse DCT on each channel of the input image \textit{pSrc} and writes the result into the corresponding channel of the output image buffer \textit{pDst}. Note that the function flavor with AC4 descriptor does not process alpha channel. This function uses the previously initialized \textit{pDCTSpec} context structure to set the mode of calculations and retrieve support data.

The function may be used with the external work buffer \textit{pBuffer} to avoid memory allocation within the functions. Once the work buffer is allocated, it can be used for all following calls to the functions computing DCT. As internal allocation of memory is too expensive operation and depends on operating system and/or runtime libraries used - the use of an external buffer improves performance significantly, especially for the small size transforms.

Before using the inverse DCT functions, you need to compute the size of the required buffers and the external work buffer using the \textit{ippiDCTInvGetSize} function.

\textbf{Return Values}

- \textbf{ippStsNoErr} Indicates no error. Any other value indicates an error or a warning.
- \textbf{ippStsNullPtrErr} Indicates an error condition if \textit{pSrc}, \textit{pDst}, or \textit{pDCTSpec} pointer is NULL.
- \textbf{ippStsStepErr} Indicates an error condition if \textit{srcStep} or \textit{dstStep} value is zero or negative.
- \textbf{ippStsContextMatchErr} Indicates an error condition if a pointer to an invalid \textit{pDCTSpec} structure is passed.
- \textbf{ippStsMemAllocErr} Indicates an error condition if memory allocation fails.

\textbf{DCT8x8Fwd}

\textit{Performs a forward DCT on a 2D buffer of 8x8 size.}

\textbf{Syntax}

\textbf{Case 1: Not-in-place operation}

\texttt{IppStatus ippiDCT8x8Fwd\_<mod>(const \textbf{Ipp<datatype> REPLACECONTENT{\textit{pSrc}}}, \textbf{Ipp<datatype> REPLACECONTENT{\textit{pDst}}});}

\textbf{Supported values for} \textit{mod}:

- 16s\_C1
- 32f\_C1

\textbf{Case 2: Not-in-place operation with ROI}

\texttt{IppStatus ippiDCT8x8Fwd\_<mod>(const \textbf{Ipp<srcDatatype> REPLACECONTENT{\textit{pSrc}}}, \textbf{int REPLACECONTENT{\textit{srcStep}}}, \textbf{Ipp<dstDatatype> REPLACECONTENT{\textit{pDst}}});}

\textbf{Supported values for} \textit{mod}:

- 16s\_C1R
- 8u16s\_C1R

\textbf{Case 3: In-place operation}

\texttt{IppStatus ippiDCT8x8Fwd\_<mod>(\textbf{Ipp<datatype> REPLACECONTENT{\textit{pSrcDst}}});}

\textbf{Supported values for} \textit{mod}:

- 16s\_C1I
- 32f\_C1I
Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

\textit{pSrc} \quad \text{Pointer to the source image buffer.}

\textit{srcStep} \quad \text{Distance in bytes between starts of consecutive lines in the source image buffer for operations with ROI.}

\textit{pDst} \quad \text{Pointer to the destination image buffer.}

\textit{pSrcDst} \quad \text{Pointer to the source and destination image for in-place operations.}

Description

Some flavors operate with ROI (see Regions of Interest in Intel IPP).

This function computes the forward discrete cosine transform of short integer or floating-point data in a 2D buffer of 8x8 size. No prerequisites are needed to use this transform function.

Return Values

\textbf{ippStsNoErr} \quad \text{Indicates no error. Any other value indicates an error or a warning.}

\textbf{ippStsNullPtrErr} \quad \text{Indicates an error condition if \textit{pSrc}, \textit{pDst}, or \textit{pSrcDst} pointer is NULL.}

\textbf{ippStsStepErr} \quad \text{Indicates an error condition if \textit{srcStep} value is zero or negative.}

Example

The code example below illustrates the use of \texttt{ippiDCT8x8Fwd} function.

\begin{verbatim}
IppStatus dct16s( void ) {
    Ipp16s x[64] = {0};
    IppiSize roi = {8,8};
    int i;
    for( i=0; i<8; ++i ) {
        ippSet_16s_C1R( (Ipp16s)i, x+8*i+i, 8*sizeof(Ipp16s), roi );
        --roi.width;
        --roi.height;
    }
    return ippiDCT8x8Fwd_16s_C1I( x );
}
\end{verbatim}
The destination image \( x \) contains:

\[
\begin{bmatrix}
18 & -9 & -2 & -1 & -1 & 0 & 0 & 0 \\
-9 & 7 & 0 & 0 & 0 & 0 & 0 & 0 \\
-2 & 0 & 2 & 0 & 0 & 0 & 0 & 0 \\
-1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
\end{bmatrix}
\]

DCT8x8Inv, DCT8x8Inv_A10

*Performs an inverse DCT on a 2D buffer of 8x8 size.*

**Syntax**

**Case 1: Not-in-place operation**

\[
\text{IppStatus ippiDCT8x8Inv}_\text{<mod>}(\text{const Ipp<datatype> }* \text{pSrc}, \text{Ipp<datatype> }* \text{pDst});
\]

Supported values for \( \text{mod} \):

16s_C1 32f_C1

IppStatus ippiDCT8x8Inv_A10_16s_C1(\text{const Ipp16s* } \text{pSrc}, \text{Ipp16s* } \text{pDst});

**Case 2: Not-in-place operation with ROI**

\[
\text{IppStatus ippiDCT8x8Inv}_\text{<mod>}(\text{const Ipp<srcDatatype> }* \text{pSrc}, \text{Ipp<dstDatatype> }* \text{pDst}, \text{int } \text{dstStep});
\]

Supported values for \( \text{mod} \):

16s_C1R 16s8u_C1R

**Case 3: In-place operation**

\[
\text{IppStatus ippiDCT8x8Inv}_\text{<mod>}(\text{Ipp<datatype> }* \text{pSrcDst});
\]

Supported values for \( \text{mod} \):

16s_C1I 32f_C1I

IppStatus ippiDCT8x8Inv_A10_16s_C1I(\text{Ipp16s* } \text{pSrcDst});

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

- `pSrc` : Pointer to the source image.
- `pDst` : Pointer to the destination buffer.
- `dstStep` : Distance in bytes between starts of consecutive lines in the destination buffer for operations with ROI.
- `pSrcDst` : Pointer to the source and destination image for in-place operations.

Description

Some flavors operate with ROI (see Regions of Interest in Intel IPP).

This function computes the inverse discrete cosine transform of data in a 2D buffer of 8x8 size. No prerequisites are needed to use this transform function.

Caution

Source data for 16s functions must be the result of the forward discrete cosine transform of data from the range \([-512, 511]\) for flavors with A10 modifier (ippiDCT8x8Inv_A10), and from the range \([-256, 255]\) for flavors without A10 modifier (ippiDCT8x8Inv); they cannot be arbitrary data from the range \([-32768, 32767]\).

Return Values

- `ippStsNoErr` : Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr` : Indicates an error condition if `pSrc`, `pDst`, or `pSrcDst` pointer is NULL.
- `ippStsStepErr` : Indicates an error condition if `dstStep` value is zero or negative.

DCT8x8FwdLS

Performs a forward DCT on a 2D buffer of 8x8 size with prior data conversion and level shift.

Syntax

```c
IppStatus ippiDCT8x8FwdLS_8u16s_C1R(const Ipp8u* pSrc, int srcStep, Ipp16s* pDst, Ipp16s addVal);
```

Include Files

- ipp.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- `pSrc` : Pointer to the source image buffer.
Description

This function operates with ROI (see Regions of Interest in Intel IPP) that is a 2D buffer of 8x8 size in this case, thus there is no need to specify its size.

This function first converts data in the buffer pSrc from unsigned Ipp8u type to the signed Ipp16s type and then performs level shift operation by adding the constant value addVal to each sample. After that, the function performs the forward discrete cosine transform of the modified data. The result is stored in pDst.

Return Values

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error condition if pSrc or pDst pointer is NULL.
- ippStsStepErr: Indicates an error condition if srcStep value is zero or negative.

DCT8x8InvLSClip

Performs an inverse DCT on a 2D buffer of 8x8 size with further data conversion and level shift.

Syntax

IppStatus ippiDCT8x8InvLSClip_16s8u_C1R(const Ipp16s* pSrc, Ipp8u* pDst, int dstStep, Ipp16s addVal, Ipp8u clipDown, Ipp8u clipUp);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- pSrc: Pointer to the source image buffer.
- pDst: Pointer to the destination image buffer.
- dstStep: Distance in bytes between starts of consecutive lines in the destination image buffer.
- addVal: The level shift value.
- clipDown: The lower bound for the range of output values.
- clipUp: The upper bound for the range of output values.
Description
This function operates with ROI (see Regions of Interest in Intel IPP) that is a 2D buffer of 8x8 size in this case, thus there is no need to specify its size.

This function performs the inverse discrete cosine transform of the buffer \( p_{Src} \). After completing the DCT, this function performs level shift operation by adding the constant value \( addVal \) to each sample. Finally, the function converts data from the signed Ipp16s type to the unsigned Ipp8u type. The output data are clipped to the range \([\text{clipDown}, \text{clipUp}]\). The result is stored in the destination buffer \( p_{Dst} \).

Caution
Source data for 16s flavors must be the result of the forward discrete cosine transform of data from the range \([-256, 255]\), they cannot be arbitrary data from the range \([-32768, 32767]\).

Return Values
- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if \( p_{Src} \) or \( p_{Dst} \) pointer is NULL.
- **ippStsStepErr**: Indicates an error condition if \( dstStep \) value is zero or negative.

DCT8x8Inv_2x2, DCT8x8Inv_4x4
Perform an inverse DCT on a top left quadrant of size 2x2 or 4x4 in the 2D buffer of size 8x8.

Syntax
- \( \text{IppStatus ippiDCT8x8Inv}_2x2_16s\_C1(\text{const Ipp16s*} \ p_{Src}, \ \text{Ipp16s*} \ p_{Dst}); \)
- \( \text{IppStatus ippiDCT8x8Inv}_4x4_16s\_C1(\text{const Ipp16s*} \ p_{Src}, \ \text{Ipp16s*} \ p_{Dst}); \)
- \( \text{IppStatus ippiDCT8x8Inv}_2x2_16s\_ClI(\text{Ipp16s*} \ p_{SrcDst}); \)
- \( \text{IppStatus ippiDCT8x8Inv}_4x4_16s\_ClI(\text{Ipp16s*} \ p_{SrcDst}); \)

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
- \( p_{Src} \): Pointer to the source image.
- \( p_{Dst} \): Pointer to the destination buffer.
- \( p_{SrcDst} \): Pointer to the source and destination buffer for in-place operations.
Description
These functions compute the inverse discrete cosine transform of non-zero elements in the top left quadrant of size 2x2 or 4x4 in the 2D buffer of 8x8 size. No prerequisites are needed to use this transform function.

Caution
Source data for 16s flavors must be the result of the forward discrete cosine transform of data from the range [-256, 255], they cannot be arbitrary data from the range [-32768, 32767].

Return Values
ippStsNoErr Indicates no error. Any other value indicates an error.
ippStsNullPtrErr Indicates an error condition if one of the specified pointers is NULL.

DCT8x8To2x2Inv, DCT8x8To4x4Inv
Perform an inverse DCT on a 2D buffer of 8x8 size with further downsampling to 2x2 or 4x4 size.

Syntax
IppStatus ippiDCT8x8To2x2Inv_16s_C1(const Ipp16s* pSrc, Ipp16s* pDst);
IppStatus ippiDCT8x8To4x4Inv_16s_C1(const Ipp16s* pSrc, Ipp16s* pDst);
IppStatus ippiDCT8x8To2x2Inv_16s_C1I(Ipp16s* pSrcDst);
IppStatus ippiDCT8x8To4x4Inv_16s_C1I(Ipp16s* pSrcDst);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pSrc Pointer to the source image.
pDst Pointer to the destination buffer.
pSrcDst Pointer to the source and destination buffer for in-place operations.

Description
These functions compute the inverse discrete cosine transform of the 2D buffer pSrc of 8x8 size. Then the functions perform downsampling of the result by averaging to the destination buffer pDst of size 2x2 or 4x4. In-place flavors of the functions perform operations on the source and destination buffer pSrcDst.
Caution
Source data for 16s flavors must be the result of the forward discrete cosine transform of data from the range \([-256, 255]\), they cannot be arbitrary data from the range \([-32768, 32767]\).

Return Values

- ippStsNoErr
  Indicates no error. Any other value indicates an error.

- ippStsNullPtrErr
  Indicates an error condition if one of the specified pointers is NULL.
This chapter describes the Intel® IPP image processing functions that can be used to compute the following statistical parameters of an image:

- sum, integrals, mean and standard deviation of pixel values
- intensity histogram of pixel values
- minimum and maximum pixel values
- spatial and central moments of order 0 to 3
- the infinity, $L_1$, and $L_2$ norms of the image pixel values and of the differences between pixel values of two images
- relative error values for the infinity, $L_1$, and $L_2$ norms of differences between pixel values of two images
- universal image quality index
- proximity measures of an image and a template (another image).

### Sum

*Computes the sum of image pixel values.*

#### Syntax

**Case 1: Operation on one-channel integer data**

```c
IppStatus ippiSum_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, Ipp64f* pSum);
```

Supported values for `mod`:

- 8u_C1R
- 16u_C1R
- 16s_C1R

**Case 2: Operation on one-channel floating-point data**

```c
IppStatus ippiSum_32f_C1R(const Ipp32f* pSrc, int srcStep, IppiSize roiSize, Ipp64f* pSum, IppHintAlgorithm hint);
```

**Case 3: Operation on multi-channel integer data**

```c
IppStatus ippiSum_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, Ipp64f sum[3]);
```

Supported values for `mod`:

- 8u_C3R
- 16u_C3R
- 16s_C3R

```c
IppStatus ippiSum_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, Ipp64f sum[4]);
```

Supported values for `mod`:

- 8u_C4R
- 16u_C4R
- 16s_C4R
Case 4: Operation on multi-channel floating-point data

IppStatus ippiSum_32f_C3R(const Ipp32f* pSrc, int srcStep, IppiSize roiSize, Ipp64f sum[3], IppHintAlgorithm hint);
IppStatus ippiSum_32f_C4R(const Ipp32f* pSrc, int srcStep, IppiSize roiSize, Ipp64f sum[4], IppHintAlgorithm hint);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc Pointer to the source image ROI.
srcStep Distance in bytes between starts of consecutive lines in the source image.
roiSize Size of the source ROI in pixels.
pSum Pointer to the computed sum of pixel values.
sum Array containing computed sums of channel values of pixels in the source buffer.
hint Option to select the algorithmic implementation of the function.

Description

This function operates with ROI (see Regions of Interest in Intel IPP). This function computes the sum of pixel values pSum for the source image pSrc using algorithm indicated by the hint argument (see Table "Hint Arguments for Image Moment Functions"). In case of a multi-channel image, the sum is computed over each channel and stored in the array sum.

Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error condition if the pSrc or pSum pointer is NULL.
ippStsSizeErr Indicates an error condition if roiSize has a field with zero or negative value.
Example

The code example below demonstrates the use of `ippiSum` function:

```c
IppStatus sum( void ) {
    Ipp64f sum;
    Ipp8u x[5*4];
    IppSize roi = {5,4};
    ippiSet_8u_C1R( 1, x, 5, roi );
    return ippiSum_8u_C1R( x, 5, roi, &sum );
}
```

Integral

*Transforms an image to the integral representation.*

**Syntax**

```c
IppStatus ippiIntegral_8u32s_C1R(const Ipp8u* pSrc, int srcStep, Ipp32s* pDst, int dstStep, IppiSize srcRoiSize, Ipp32s val);
IppStatus ippiIntegral_8u32f_C1R(const Ipp8u* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize srcRoiSize, Ipp32f val);
IppStatus ippiIntegral_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize srcRoiSize);
```

**Include Files**

`ippcv.h`

**Domain Dependencies**

**Headers:** `ippcore.h`, `ippvm.h`, `ipps.h`, `ippi.h`

**Libraries:** `ippcore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`

**Parameters**

- `pSrc`: Pointer to the source image ROI.
- `srcStep`: Distance in bytes between starts of consecutive lines in the source image.
- `pDst`: Pointer to the ROI in the destination integral image.
- `dstStep`: Distance in bytes between starts of consecutive lines in the destination image.
- `srcRoiSize`: Size of source and destination image ROI in pixels.
- `val`: The value to add to `pDst` image pixels.
Description

This function operates with ROI (see Regions of Interest in Intel IPP). This function transforms a source image \( pSrc \) to the integral image \( pDst \). Pixel values of the destination image \( pDst \) are computed using pixel values of the source image \( pSrc \) and the specified value \( \text{val} \) in accordance with the following formula:

\[
pDst[i, j] = \text{val} + \sum_{k<i} \sum_{l<j} pSrc[k, l]
\]

where \( i,j \) are coordinates of the destination image pixels (see Figure 11-1) varying in the range \( i = 1, \ldots, \text{srcRoiSize.height}, j = 0, \ldots, \text{srcRoiSize.width} \). Pixel values of zero row and column of \( pDst \) \( (i=0) \) is set to \( \text{val} \).

For the \texttt{ippiIntegral\_32f\_C1} function flavor the value of \( \text{val} \) is considered to be equal to zero.

The size of the destination images is \( (\text{srcRoiSize.width} + 1) \times (\text{srcRoiSize.height} + 1) \).

Figure “Operation of the Integral and TiltedIntegral functions” shows what pixels (red circles) of the source image are used in computation new pixel values in the \( i,j \) coordinates.

For large images the result of summation can exceed the upper bound of the output data type. Table “Maximum Image Size for Integral Functions” lists the maximum image size for different function flavors and values.

Operation of the Integral and TiltedIntegral functions

| Maximum Image Size for Integral Functions |
|-------------------|-------------------|-------------------|
| **Function Flavor** | **Value \( \text{val} \)** | **Maximum Image Size** |
| \texttt{ippiIntegral\_8u32a\_C1R} | 0                 | \( (2^{31}-1)/255 \) |
| \texttt{ippiIntegral\_8u32f\_C1R} | 0                 | \( 2^{24}/255 \)   |

<table>
<thead>
<tr>
<th><strong>Return Values</strong></th>
</tr>
</thead>
</table>

\texttt{ippStsNoErr}  
Indicates no error.

\texttt{ippStsNullPtrErr}  
Indicates an error if \( pSrc \) or \( pDst \) is \texttt{NULL}.

\texttt{ippStsSizeErr}  
Indicates an error condition if \( \text{srcRoiSize} \) has a field with zero or negative value.
**ippStsStepErr**
Indicates an error condition if srcStep is less than srcRoiSize.width * <pixelSize>, or dstStep is less than (srcRoiSize.width+1) * <pixelSize>.

**ippStsNotEvenStepErr**
Indicates an error condition if srcStep or dstStep is not divisible by <pixelSize>.

**Example**

The code example below demonstrates how to use the ippiIntegral_8u32s_C1R function:

```c
void func_integral_8u32s_C1R()
{
  Ipp8u pSrc[5*4];
  Ipp32s pDst[6*5];
  IppSize ROI = {5,4};
  ippiSet_8u_C1R(1,pSrc,5,ROI);
  Ipp32s val = 1;
  ippiIntegral_8u32s_C1R(pSrc, 5, pDst, 6*sizeof(Ipp32s), ROI, val);
}
```

Result:

<table>
<thead>
<tr>
<th>pSrc</th>
<th>pDst</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1 1 1</td>
<td>1 1 1 1</td>
</tr>
<tr>
<td>1 1 1 1</td>
<td>1 2 3 4</td>
</tr>
<tr>
<td>1 1 1 1</td>
<td>1 3 5 7</td>
</tr>
<tr>
<td>1 1 1 1</td>
<td>1 4 7 10</td>
</tr>
</tbody>
</table>

The code example below demonstrates how to use the ippiIntegral_32f_C1R function:

```c
void func_integral_32f_C1R()
{
  Ipp32f pSrc[5*4];
  Ipp32f pDst[6*5];
  IppSize ROI = {5,4};
  ippiSet_32f_C1R(1, pSrc, 5*sizeof(Ipp32f), ROI);
  ippiIntegral_32f_C1R(pSrc, 5*sizeof(Ipp32f), pDst, 6*sizeof(Ipp32f), ROI);
}
```

Result:

<table>
<thead>
<tr>
<th>pSrc</th>
<th>pDst</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 1.0 1.0 1.0 1.0</td>
<td>0.0 0.0 0.0 0.0 0.0 0.0</td>
</tr>
<tr>
<td>1.0 1.0 1.0 1.0 1.0</td>
<td>0.0 0.0 0.0 0.0</td>
</tr>
<tr>
<td>1.0 1.0 1.0 1.0 1.0</td>
<td>0.0 1.0 2.0 3.0</td>
</tr>
<tr>
<td>1.0 1.0 1.0 1.0 1.0</td>
<td>0.0 2.0 4.0 6.0</td>
</tr>
</tbody>
</table>

**SqrIntegral**
Transforms an image to integral and integral of pixel squares representations.

**Syntax**

```c
IppStatus ippiSqrIntegral_8u32s64f_C1R(const Ipp8u* pSrc, int srcStep, Ipp32s* pDst, int dstStep, Ipp64f* pSqr, int sqrStep, IppSize roiSize, Ipp32s val, Ipp64f valSqr);
```

```c
IppStatus ippiSqrIntegral_8u32f64f_C1R(const Ipp8u* pSrc, int srcStep, Ipp32f* pDst, int dstStep, Ipp64f* pSqr, int sqrStep, IppSize roiSize, Ipp32f val, Ipp64f valSqr);
```
IppStatus ippiSqrIntegral_8u32s_C1R(const Ipp8u* pSrc, int srcStep, Ipp32s* pDst, int dstStep, Ipp32s* pSqr, int sqrStep, IppiSize roiSize, Ipp32s val, Ipp32s valSqr);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
pSrc
Pointer to the source image ROI.
srcStep
Distance in bytes between starts of consecutive lines in the source image.
pDst
Pointer to the ROI in the destination integral image.
dstStep
Distance in bytes between starts of consecutive lines in the destination image.
pSqr
Pointer to the ROI of the destination integral image of pixel squares.
sqrStep
Distance in bytes between starts of consecutive lines in the destination integral image of pixel squares.
roiSize
Size of source image ROI in pixels.
val
The value to add to pDst image pixels.
valSqr
The value to add to pSqr image pixels

Description
This function operates with ROI (see Regions of Interest in Intel IPP). This function builds two destination images: integral image pDst and integral image of pixel squares pSqr. Pixel values of pDst are computed using pixel values of the source image pSrc and the specified value val in accordance with the following formula:

\[ p_{Dst}[i, j] = v_{al} + \sum_{k<i} \sum_{l<j} p_{Src}[k, l] \]

Pixel values of pSqr are computed using pixel values of the source image pSrc and the specified value valSqr in accordance with the following formula:

\[ p_{Sqr}[i, j] = v_{alSqr} + \sum_{k<i} \sum_{l<j} p_{Src}[k, l]^2 \]

where \( i, j \) are coordinates of the destination image pixels (see Figure “Operation of the Integral and TiltedIntegral functions”) varying in the range \( i = 1, ..., roiSize.height, j = 0, ..., roiSize.width \). Pixel values of zero row and column are set to val for pDst, and to valSqr for pSqr. The size of both destination images is \((roiSize.width + 1) \times (roiSize.height + 1)\).

Figure “Operation of the Integral and TiltedIntegral functions” shows what pixels (red circles) of the source image are used in computation new pixel values in the \( i, j \) coordinates.
Return Values

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoEr</td>
<td>Indicates no error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error if one of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error condition if roiSize has a field with zero or negative value.</td>
</tr>
<tr>
<td>ippStsStepErr</td>
<td>Indicates an error condition if srcStep is less than roiSize.width * &lt;pixelSize&gt;, or dstStep or sqrStep is less than (roiSize.width+1) * &lt;pixelSize&gt;.</td>
</tr>
<tr>
<td>ippStsNotEvenStepErr</td>
<td>Indicates an error condition if dstStep is not divisible by 4, or sqrStep is not divisible by 8.</td>
</tr>
</tbody>
</table>

TiltedIntegral

**Transforms an image to the tilted integral representation.**

**Syntax**

IppStatus ippiTiltedIntegral_8u32f_C1R(const Ipp8u* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, Ipp32f val);

IppStatus ippiTiltedIntegral_8u32s_C1R(const Ipp8u* pSrc, int srcStep, Ipp32s* pDst, int dstStep, IppiSize roiSize, Ipp32s val);

**Include Files**

ippcv.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**
  Pointer to the source image ROI.

- **srcStep**
  Distance in bytes between starts of consecutive lines in the source image.

- **pDst**
  Pointer to the ROI in the destination integral image.

- **dstStep**
  Distance in bytes between starts of consecutive lines in the destination image.

- **roiSize**
  Size of source image ROI in pixels.

- **val**
  The value to add to pDst image pixels

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP). This function transforms a source image **pSrc** to the tilted integral image **pDst**. Pixel values of the destination image **pDst** are computed using pixel values of the source image **pSrc** and the specified value **val** in accordance with the following formula:
where \( i, j \) are coordinates of the destination image pixels (see Figure "Operation of the Integral and TiltedIntegral functions") varying in the range \( i = 2, \ldots, \text{roiSize.height} + 1, j = 0, \ldots, \text{roiSize.width} + 1 \). Pixel values of rows 0 and 1 of the destination image \( pDst(i=0) \) is set to \( \text{val} \).

The size of the destination images is \((\text{roiSize.width} + 2) \times (\text{roiSize.height} + 2)\).

Figure "Operation of the Integral and TiltedIntegral functions" shows what pixels (red circles) of the source image are used in computation new pixel values in the \( i, j \) coordinates.

### Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error if \( pSrc \) or \( pDst \) is \( \text{NULL} \).
- **ippStsSizeErr**: Indicates an error condition if \( \text{roiSize} \) has a field with zero or negative value.
- **ippStsStepErr**: Indicates an error condition if \( \text{srcStep} \) is less than \( \text{roiSize.width} \times \text{<pixelSize>} \), or \( \text{dstStep} \) is less than \((\text{roiSize.width}+2) \times \text{<pixelSize>}\).
- **ippStsNotEvenStepErr**: Indicates an error condition if one \( \text{dstStep} \) is not divisible by 4.

### TiltedSqrIntegral

**Transforms an image to tilted integral and tilted integral of pixel squares representations.**

**Syntax**

```c
IppStatus ippiTiltedSqrIntegral_8u32s_C1R(const Ipp8u* pSrc, int srcStep, Ipp32s* pDst, int dstStep, Ipp32s* pSqr, int sqrStep, IppiSize roiSize, Ipp32s val, Ipp32s valSqr);
IppStatus ippiTiltedSqrIntegral_8u32s64f_C1R(const Ipp8u* pSrc, int srcStep, Ipp32s* pSqr, int sqrStep, IppiSize roiSize, Ipp32s val, Ipp64f valSqr);
IppStatus ippiTiltedSqrIntegral_8u32f64f_C1R(const Ipp8u* pSrc, int srcStep, Ipp32f* pSqr, int sqrStep, IppiSize roiSize, Ipp32f val, Ipp64f valSqr);
```

**Include Files**

ippcv.h

**Domain Dependencies**

- **Headers**: ippcore.h, ippvm.h, ipps.h,ippi.h
- **Libraries**: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**: Pointer to the source image ROI.
srcStep
Distance in bytes between starts of consecutive lines in the source image.

pDst
Pointer to the ROI in the destination integral image.

dstStep
Distance in bytes between starts of consecutive lines in the destination image.

pSqr
Pointer to the ROI of the destination integral image of pixel squares.

sqrStep
Distance in bytes between starts of consecutive lines in the destination integral image of pixel squares.

roiSize
Size of source image ROI in pixels.

val
The value to add to pDst image pixels.

valSqr
The value to add to pSqr image pixels.

Description
This function operates with ROI (see Regions of Interest in Intel IPP). This function builds two destination images: tilted integral image pDst and tilted integral image of pixel squares pSqr.

Pixel values of pDst are computed using pixel values of the source image pSrc and the specified value val in accordance with the following formula:

\[ p_{Dst}[i,j] = val + \sum_{k-1 \leq l \leq j+1} \sum_{k+1 \leq l \leq j-2} p_{Src}[k,l] \]

Pixel values of pSqr are computed using pixel values of the source image pSrc and the specified value valSqr in accordance with the following formula:

\[ p_{Sqr}[i,j] = valSqr + \sum_{k-1 \leq l \leq j+1} \sum_{k+1 \leq l \leq j-2} p_{Src}[k,l]^2 \]

where \(i, j\) are coordinates of the destination image pixels (see Figure “Operation of the Integral and TiltedIntegral functions”) varying in the range \(i = 2, ..., roi\text{Size}.height, j = 0, ..., roi\text{Size}.width\). Pixel values of zero and first rows \((i=0,1)\) are set to val for pDst, and to valSqr for pSqr. The size of both destination images is \((roi\text{Size}.width + 2) \times (roi\text{Size}.height + 2)\).

Figure “Operation of the Integral and TiltedIntegral functions” shows what pixels (red circles) of the source image are used in computation new pixel values in the \(i, j\) coordinates.

Return Values

ippStsNoErr
Indicates no error.

ippStsNullPtrErr
Indicates an error if one of the specified pointers is NULL.

ippStsSizeErr
Indicates an error condition if roiSize has a field with zero or negative value.

ippStsStepErr
Indicates an error condition if srcStep is less than roiSize.width * <pixelSize>, or dstStep or sqrStep is less than (roiSize.width+2) * <pixelSize>.

ippStsNotEvenStepErr
Indicates an error condition if dstStep is not divisible by 4, or sqrStep is not divisible by 8.
Mean

*Comptes the mean of image pixel values.*

**Syntax**

**Case 1: Operation on one-channel integer data**

```c
IppStatus ippiMean_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppSize roiSize,
Ipp64f* pMean);
```

Supported values for `mod`:

- 8u_C1R
- 16u_C1R
- 16s_C1R

**Case 2: Operation on one-channel floating-point data**

```c
IppStatus ippiMean_32f_C1R(const Ipp32f* pSrc, int srcStep, IppSize roiSize, Ipp64f* pMean, IppHintAlgorithm hint);
```

**Case 3: Masked operation on one-channel data**

```c
IppStatus ippiMean_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp8u* pMask,
int maskStep, IppSize roiSize, Ipp64f* pMean);
```

Supported values for `mod`:

- 8u_C1MR
- 16u_C1MR
- 32f_C1MR

**Case 4: Operation on multi-channel integer data**

```c
IppStatus ippiMean_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppSize roiSize,
Ipp64f mean[3]);
```

Supported values for `mod`:

- 8u_C3R
- 16u_C3R
- 16s_C3R

```c
IppStatus ippiMean_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppSize roiSize,
Ipp64f mean[4]);
```

Supported values for `mod`:

- 8u_C4R
- 16u_C4R
- 16s_C4R

**Case 5: Operation on multi-channel floating-point data**

```c
IppStatus ippiMean_32f_C4R(const Ipp32f* pSrc, int srcStep, IppSize roiSize, Ipp64f
mean[3], IppHintAlgorithm hint);
```

Supported values for `mod`:

- 32f_C3R

```c
IppStatus ippiMean_32f_C4R(const Ipp32f* pSrc, int srcStep, IppSize roiSize, Ipp64f
mean[4], IppHintAlgorithm hint);
```
Case 6: Masked operation on multi-channel data

IppStatus ippiMean_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp8u* pMask, int maskStep, IppiSize roiSize, int coi, Ipp64f* pMean);

Supported values for `<mod>`:

- 8u_C3CMR
- 16u_C3CMR
- 32f_C3CMR

Include Files

ippi.h
ippcv.h

Domain Dependencies

Flavors declared in ippi.h:
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippcv.h:
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- `<pSrc>` Pointer to the source image ROI.
- `<srcStep>` Distance in bytes between starts of consecutive lines in the source image.
- `<pMask>` Pointer to the mask image.
- `<maskStep>` Distance in bytes between starts of consecutive lines in the mask image.
- `<roiSize>` Size of the source ROI in pixels.
- `<coi>` Channel of interest (for color images only); can be 1, 2, or 3.
- `<pMean>` Pointer to the computed mean of pixel values.
- `<mean>` Array containing computed mean values for each channel of a multi-channel image.
- `<hint>` Option to select the algorithmic implementation of the function.

Description

The flavors of the function `ippiMean` that perform masked operations are declared in the ippcv.h file. All other function flavors are declared in the ippi.h file. This function operates with ROI (see Regions of Interest in Intel IPP). It computes the mean (average) of pixel values `<pMean>` for the source image `<pSrc>`. Computation algorithm is specified by the `<hint>` argument (see Table "Hint Arguments for Image Moment Functions"). For non-masked operations on a multi-channel image (Case 4, 5), the mean is computed over each channel and stored in the array `<mean>`. In the mask multi-channel mode (Case 6), the mean is computed for a single channel of interest specified by `<coi>`.
Return Values
ippStsNoErr
Indicates no error. Any other value indicates an error or a
warning.
ippStsNullPtrErr
Indicates an error when any of the specified pointers is NULL.
ippStsSizeErr
Indicates an error condition if roiSize has a field with zero or
negative value.
ippStsStepErr
Indicates an error condition in mask mode, if srcStep or
maskStep is less than roiSize.width * <pixelSize>.
ippStsNotEvenStepErr
Indicates an error condition in mask mode if steps for floating-
point images cannot be divided by 4.
ippStsCOIErr
Indicates an error when coi is not 1, 2, or 3.

Example
The code example below shows how to use the ippiMean function.

```c
IppStatus mean( void ) { 
    Ipp64f mean;
    Ipp8u x[5*4];
    IppiSize roi = {5,4};
    ippiSet_8u_C1R( 3, x, 5, roi);
    return ippiMean_8u_C1R( x, 5, roi, &mean );
}
```

Mean_StdDev

Computes the mean and standard deviation of image
pixel values.

Syntax
Case 1: Operation on one-channel data
IppStatus ippiMean_StdDev_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize
roiSize, Ipp64f* pMean, Ipp64f* pStdDev);

Supported values for mod:

<table>
<thead>
<tr>
<th>mod</th>
<th>8u_C1R</th>
<th>16u_C1R</th>
<th>32f_C1R</th>
</tr>
</thead>
</table>

Case 2: Masked operation on one-channel data
IppStatus ippiMean_StdDev_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp8u* 
pMask, int maskStep, IppiSize roiSize, Ipp64f* pMean, Ipp64f* pStdDev);

Supported values for mod:

<table>
<thead>
<tr>
<th>mod</th>
<th>8u_C1MR</th>
<th>16u_C1MR</th>
<th>32f_C1MR</th>
</tr>
</thead>
</table>

Case 3: Operation on multi-channel data

```c
IppStatusippiMean_StdDev_<mod>(const Ipp<datatype>*pSrc, int srcStep, IppSize roiSize, int coi, Ipp64f* pMean, Ipp64f* pStdDev);
```

Supported values for `mod`:

- 8u_C3CR
- 16u_C3CR
- 32f_C3CR

Case 4: Masked operation on multi-channel data

```c
IppStatusippiMean_StdDev_<mod>(const Ipp<datatype>*pSrc, int srcStep, const Ipp8u*pMask, int maskStep, IppSize roiSize, int coi, Ipp64f* pMean, Ipp64f* pStdDev);
```

Supported values for `mod`:

- 8u_C3CMR
- 16u_C3CMR
- 32f_C3CMR

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- `pSrc` Pointer to the source image ROI.
- `srcStep` Distance in bytes between starts of consecutive lines in the source image.
- `pMask` Pointer to the mask image.
- `maskStep` Distance in bytes between starts of consecutive lines in the mask image.
- `roiSize` Size of the source ROI in pixels
- `coi` Channel of interest (for color images only); can be 1, 2, or 3.
- `pMean` Pointer to the computed mean of pixel values.
- `pStdDev` Pointer to the computed standard deviation of pixel values in the image.

Description

This function operates with ROI (see Regions of Interest in Intel IPP). This function computes the mean and standard deviation of pixel values in the ROI of the source image `pSrc`. In the mask mode, the computation is done over pixels selected by nonzero mask values. In the multi-channel mode, the mean is computed for a single channel of interest specified by `coi`. If any of the parameters `pMean` or `pStdDev` is not required, the zero pointer is to be passed to the corresponding parameter.

Return Values

- **ippStsNoErr** Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr** Indicates an error when `pSrc` or `pMask` pointer is NULL.
Indicates an error condition if roiSize has a field with zero or negative value.

Indicates an error condition if srcStep or maskStep is less than roiSize.width * pixelSize.

Indicates an error condition if steps for floating-point images cannot be divided by 4.

Indicates an error when coi is not 1, 2, or 3.

**RectStdDev**

Computes the standard deviation of the integral images.

**Syntax**

IppStatus ippiRectStdDev_32f_C1R(const Ipp32f* pSrc, int srcStep, const Ipp64f* pSqr, int sqrStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiRect rect);

IppStatus ippiRectStdDev_32s32f_C1R(const Ipp32s* pSrc, int srcStep, const Ipp64f* pSqr, int sqrStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiRect rect);

IppStatus ippiRectStdDev_32s_C1RSfs(const Ipp32s* pSrc, int srcStep, const Ipp32s* pSqr, int sqrStep, Ipp32s* pDst, int dstStep, IppiSize roiSize, IppiRect rect, int scaleFactor);

**Include Files**

ippcv.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**
  - Pointer to the ROI in the source integral image.

- **srcStep**
  - Distance in bytes between starts of consecutive lines in the source integral image.

- **pSqr**
  - Pointer to the ROI in the source integral image of pixel squares.

- **sqrStep**
  - Distance in bytes between starts of consecutive lines in the source integral image of pixel squares.

- **pDst**
  - Pointer to the destination image ROI.

- **dstStep**
  - Distance in bytes between starts of consecutive lines in the destination image.

- **roiSize**
  - Size of destination image ROI in pixels.

- **rect**
  - Rectangular window.

- **scaleFactor**
  - Scale factor (see Integer Result Scaling).
Description

This function operates with ROI (see Regions of Interest in Intel IPP). This function computes the standard deviation for each pixel in the rectangular window $\text{rect}$ using the integral image $\text{pSrc}$ and integral image of pixel squares $\text{pSqr}$. The computations are performed in accordance with the following formulas:

$$pDst[i, j] = \max\left(0, \frac{\text{sumSqr} \cdot \text{numPix} - \text{sum}^2}{\text{numPix}^2}\right)$$

where $i, j$ are coordinates of the destination image pixels varying in the range $i = 0, ..., \text{roiSize.height} - 1$, $j = 0, ..., \text{roiSize.width} - 1$;

$\text{sum} = \text{pSrc}[i + \text{rect.y + rect.height}, j + \text{rect.x + rect.width}] - \text{pSrc}[i + \text{rect.y}, j + \text{rect.x + rect.width}] - \text{pSrc}[i + \text{rect.y + rect.height}, j + \text{rect.x}] + \text{pSrc}[i + \text{rect.y}, j + \text{rect.x}]$;

$\text{sumSqr} = \text{pSqr}[i + \text{rect.y + rect.height}, j + \text{rect.x + rect.width}] - \text{pSqr}[i + \text{rect.y}, j + \text{rect.x + rect.width}] - \text{pSqr}[i + \text{rect.y + rect.height}, j + \text{rect.x}] + \text{pSqr}[i + \text{rect.y}, j + \text{rect.x}]$;

$\text{numPix} = \text{rect.height} \cdot \text{rect.width}$.

The minimum size of each source images $\text{pSrc}$ and $\text{pSqr}$ should be $(\text{roiSize.width + rect.x + rect.width}) \times (\text{roiSize.height + rect.y + rect.height})$.

The source images $\text{pSrc}$ and $\text{pSqr}$ can be obtained by using the functions $\text{ippiIntegral}$ or $\text{ippiSqrIntegral}$.

Return Values

- **ippiStsNoErr**: Indicates no error.
- **ippiStsNullPtrErr**: Indicates an error if one of the specified pointers is NULL.
- **ippiStsSizeErr**: Indicates an error condition if $\text{roiSize}$ has a field with zero or negative value.
- **ippiStsSizeErr**: Indicates an error condition if $\text{rect.width}$ or $\text{rect.height}$ is less than or equal to zero, or if $\text{rect.x}$ or $\text{rect.y}$ is less than zero.
- **ippiStsStepErr**: Indicates an error condition if $\text{srcStep}$ or $\text{sqrStep}$ is less than $(\text{roiSize.width+rect.x+rect.width+1}) \times <\text{pixelSize}>$, or $\text{dstStep}$ is less than $\text{roiSize.width} \times <\text{pixelSize}>$.
- **ippiStsNotEvenStepErr**: Indicates an error condition if $\text{sqrStep}$ is not divisible by 8, or one of $\text{pSrc}$ and $\text{dstStep}$ is not divisible by 4.

TiltedRectStdDev

*Computes the standard deviation of the tilted integral images.*

**Syntax**

IppStatus ippiTiltedRectStdDev_32f_C1R(const Ipp32f* $\text{pSrc}$, int $\text{srcStep}$, const Ipp64f* $\text{pSqr}$, int $\text{sqrStep}$, Ipp32f* $\text{pDst}$, int $\text{dstStep}$, IppiSize $\text{roiSize}$, IppiRect $\text{rect}$);

IppStatus ippiTiltedRectStdDev_32s_C1RSfs(const Ipp32s* $\text{pSrc}$, int $\text{srcStep}$, const Ipp32s* $\text{pSqr}$, int $\text{sqrStep}$, Ipp32s* $\text{pDst}$, int $\text{dstStep}$, IppiSize $\text{roiSize}$, IppiRect $\text{rect}$, int $\text{scaleFactor}$);
IppStatusippiTiltedRectStdDev_32s32f_C1R(const Ipp32s* pSrc, int srcStep, const
Ipp64f* pSqr, int sqrStep, Ipp32f* pDst, int dstStep, IppSize roiSize, IppiRect rect);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipp.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipp.lib,ippi.lib

Parameters
pSrc      Pointer to the ROI in the source integral image.
srcStep   Distance in bytes between starts of consecutive lines in the
          source integral image.
pSqr      Pointer to the ROI in the source integral image of pixel squares.
sqrStep   Distance in bytes between starts of consecutive lines in the
          source integral image of pixel squares.
pDst      Pointer to the destination image ROI.
dstStep   Distance in bytes between starts of consecutive lines in the
          destination image.
roiSize   Size of destination image ROI in pixels.
rect      Rectangular window.
scaleFactor Scale factor (see Integer Result Scaling).

Description
This function operates with ROI (see Regions of Interest in Intel IPP). This function computes the standard
deviation for each pixel in the rectangular window rect using the tilted integral image pSrc and tilted
integral image of pixel squares pSqr. The computations are performed in accordance with the following
formulas:

$$
pDst[i,j] = \max\left(0, \frac{\text{sumSqr} \cdot \text{numPix} - \text{sum}^2}{\text{numPix}^2}\right)
$$

where $i, j$ are coordinates of the destination image pixels varying in the range $i = 0,\ldots,\text{roiSize.height} - 1,$ $j = 0,\ldots,\text{roiSize.width} - 1$;

$$
\text{sum} = pSrc[i + \text{rect.x} + \text{rect.y} + \text{rect.height} + \text{rect.width}, j + \text{rect.x} + \text{rect.y} - \text{rect.height} + \text{rect.width}] - pSrc[i + \text{rect.x} - \text{rect.y} + \text{rect.width}, j + \text{rect.x} + \text{rect.y} + \text{rect.width}] - pSrc[i + \text{rect.x} - \text{rect.y} + \text{rect.height}, j + \text{rect.x} - \text{rect.y} - \text{rect.height}] + pSrc[i + \text{rect.x} - \text{rect.y}, j + \text{rect.x} + \text{rect.y}];
$$

$$
\text{sumSqr} = pSqr[i + \text{rect.x} - \text{rect.y} + \text{rect.height} + \text{rect.width}, j + \text{rect.x} + \text{rect.y} - \text{rect.height} + \text{rect.width}] - pSqr[i + \text{rect.x} - \text{rect.y} + \text{rect.width}, j + \text{rect.x} + \text{rect.y} + \text{rect.width}] - pSqr[i + \text{rect.x} - \text{rect.y} + \text{rect.height}, j + \text{rect.x} - \text{rect.y} - \text{rect.height}] + pSqr[i + \text{rect.x} - \text{rect.y}, j + \text{rect.x} + \text{rect.y}];
$$

$$
\text{numPix} = 2 \cdot \text{rect.height} \cdot \text{rect.width}.
$$
The minimum size of each source images \( pSrc \) and \( pSqr \) should be \((roiSize.width + rect.height + rect.width - 2) \times (roiSize.height + rect.x + rect.y + rect.height + rect.width - 2)\).

The source images \( pSrc \) and \( pSqr \) can be obtained by using the functions `ippiTiltedIntegral` or `ippiTiltedSqrIntegral`.

**Return Values**

- `ippStsNoErr`: Indicates no error.
- `ippStsNullPtrErr`: Indicates an error if one of the specified pointers is NULL.
- `ippStsSizeErr`: Indicates an error condition if `roiSize` has a field with zero or negative value.
- `ippStsSizeErr`: Indicates an error condition if `rect.width` or `rect.height` is less than or equal to zero, or if `rect.x` or `rect.y` is less than zero.
- `ippStsStepErr`: Indicates an error condition if `srcStep` or `sqrStep` is less than \((roiSize.width+rect.x+rect.width+1) \times \text{<pixelSize>}, \) or `dstStep` is less than \(roiSize.width \times \text{<pixelSize>}\).
- `ippStsNotEvenStepErr`: Indicates an error condition if `sqrStep` is not divisible by 8, or one of `pSrc` and `dstStep` is not divisible by 4.

**HistogramGetBufferSize**

*Computes the size of the specification structure and work buffer for the `ippiHistogram` function.*

**Syntax**

```c
IppStatus ippiHistogramGetBufferSize(IppDataType dataType, IppiSize roiSize, const int nLevels[], int numChannels, int uniform, int* pSpecSize, int* pBufferSize);
```

**Include Files**

`ippi.h`

**Domain Dependencies**

Headers: `ippcore.h`, `ippvm.h`, `ipps.h`

Libraries: `ippcore.lib`, `ippvm.lib`, `ipps.lib`

**Parameters**

- `dataType`: Data type of the source image. Supported values are: `ipp8u`, `ipp16u`, `ipp16s`, and `ipp32f`.
- `roiSize`: Size of the source image ROI, in pixels.
- `nLevels`: Number of level values. Each channel has a separate number of levels.
- `numChannels`: Number of image channels. Supported values are: 1, 3, and 4.
- `uniform`: Type of levels distribution: 0 - with random step, 1 - with uniform step.
### pSpecSize
Pointer to the computed value of the specification structure size, in bytes.

### pBufferSize
Pointer to the computed value of the external buffer size.

### Description
The **ippiHistogramGetBufferSize** function computes the size of the histogram specification structure and the size of the external work buffer (in bytes) needed for the **Histogram** function.

For an example on how to use this function, refer to the example provided with the **Histogram** function description.

### Return Values
- **ippiStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.
- **ippiStsNullPtrErr**
  Indicates an error when one of the specified pointers is NULL.
- **ippiStsSizeErr**
  Indicates an error when **roiSize** is less than, or equal to zero.
- **ippiStsHistoNofLevelsErr**
  Indicates an error when the number of levels is less than 2.
- **ippiStsNumChannelsErr**
  Indicates an error when the **numChannels** value differs from 1, 3, or 4.
- **ippiStsDataTypeErr**
  Indicates an error when the **dataType** value differs from **ipp8u**, **ipp16u**, **ipp16s**, or **ipp32f**.

### See Also
- **Histogram** Computes the intensity histogram of an image.

---

### HistogramGetLevels
*Returns the array with level values stored in the specification structure.*

#### Syntax
```
IppStatus ippiHistogramGetLevels(const IppiHistogramSpec* pSpec, Ipp32f* pLevels[]);
```

#### Include Files
```
ippi.h
```

#### Domain Dependencies
- **Headers**: ippcore.h, ippvm.h, ipps.h
- **Libraries**: ippcore.lib, ippvm.lib, ipps.lib

#### Parameters
- **pSpec**: Pointer to the specification structure.
- **pLevels**: Pointer to the array of pointers to the level values vectors for each channel.

#### Description
The **ippiHistogramGetLevels** function returns the level values stored in the histogram specification structure.
For an example on how to use this function, refer to the example provided with the Histogram function description.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when one of the specified pointers is NULL.
- **ippStsBadArgErr**: Indicates an error when the pSpec object is not initialized.

**See Also**

Histogram Computes the intensity histogram of an image.

**HistogramInit, HistogramUniformInit**

*Initializes the specification structure for the ippiHistogram function.*

**Syntax**

```c
IppStatus ippiHistogramInit(IppDataType dataType, const Ipp32f* pLevels[], int nLevels[], int numChannels, IppiHistogramSpec* pSpec);
IppStatus ippiHistogramUniformInit(IppDataType dataType, Ipp32f lowerLevel[], Ipp32f upperLevel[], int nLevels[], int numChannels, IppiHistogramSpec* pSpec);
```

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **dataType**: Data type of the source image. Supported values are: ipp8u, ipp16u, ipp16s, and ipp32f.
- **pLevels**: Pointer to the array of pointers to the level values vectors for each channel.
- **lowerLevel**: Lower levels for uniform histogram, separate for each channel.
- **upperLevel**: Upper levels for uniform histogram, separate for each channel.
- **nLevels**: Number of level values. Each channel has a separate number of levels.
- **numChannels**: Number of image channels. Supported values are: 1, 3, and 4.
- **pSpec**: Pointer to the specification structure.

**Description**

The ippiHistogramInit function initializes the specification structure for the Histogram function.

For an example on how to use these functions, refer to the example provided with the Histogram function description.
Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error when one of the specified pointers is NULL.
ippStsSizeErr Indicates an error when roiSize is less than, or equal to zero.
ippStsHistoNofLevelsErr Indicates an error when the number of levels is less than 2.
ippStsNumChannelsErr Indicates an error when the numChannels value differs from 1, 3, or 4.
ippStsDataTypeErr Indicates an error when the dataType value differs from ipp8u, ipp16u, ipp16s, or ipp32f.

See Also
Histogram Computes the intensity histogram of an image.

Histogram

Computes the intensity histogram of an image.

Syntax

Case 1: One-channel data

IppStatus ippiHistogram_<mod>(const Ipp<dataType>* pSrc, int srcStep, IppSize roiSize, Ipp32u* pHist, const IppHistogramSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C1R 16u_C1R 16s_C1R 32f_C1R

Case 2: Three-channel data

IppStatus ippiHistogram_<mod>(const Ipp<dataType>* pSrc, int srcStep, IppSize roiSize, Ipp32u* pHist[3], const IppHistogramSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C3R 16u_C3R 16s_C3R 32f_C3R

Case 3: Four-channel data

IppStatus ippiHistogram_<mod>(const Ipp<dataType>* pSrc, int srcStep, IppSize roiSize, Ipp32u* pHist[4], const IppHistogramSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C4R 16u_C4R 16s_C4R 32f_C4R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance, in bytes, between the starting points of consecutive lines in the source image.
- **roiSize**: Size of the source image ROI, in pixels.
- **pHist**: Pointer to the computed histogram. In case of multi-channel data, `pHist` is an array of pointers to the histogram for each channel.
- **pSpec**: Pointer to the specification structure.
- **pBuffer**: Pointer to the work buffer.

Description

The `ippiHistogram` function operates with ROI (see Regions of Interest in Intel IPP). This function computes the intensity histogram for each channel of the source image and stores the result in the `pHist` array.

Before calling this function, initialize the specification structure using the `HistogramInit` or `HistogramUniformInit` functions. The specification structure defines the following parameters for histogram calculation:

- Histogram type: with uniform or random levels step
- Number of levels
- Level values

Length of the `pHist` array is defined by the `nLevels` parameter passed to the `HistogramInit` or `HistogramUniformInit` function.

As `nLevels` is the number of levels, the number of values in the `pHist` array, which is the number of histogram bins, is `nLevels - 1`. The meaning of the `pHist` and `pLevels` values can be illustrated by the following example: `pHist[k]` is the number of the source image pixels `pSrc(x, y)` that satisfy the condition `pLevels[k] <= pSrc(x, y) < pLevels[k+1].`

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error when `roiSize` has a zero or negative value.
- **ippStsStepErr**: Indicates an error when `srcStep` is less than `roiSize.width*sizeOf(*pSrc)*nChannels`.
- **ippStsBadArgErr**: Indicates an error when the `pSpec` object is not initialized.

Example

The code example below demonstrates how to use the `HistogramGetBufferSize`, `HistogramUniformInit`, `HistogramGetLevels`, and `Histogram` functions.

```c
void HistogramExample()
{
    const int HEIGHT = 8;
```
const int WIDTH = 8;
Ipp8u pImg[WIDTH*HEIGHT];
IppiSize roi = {WIDTH, HEIGHT};
int 1;
IppStatus sts;
{
    // fill image with random values in [0..255] range with uniform distribution.
    IppsRandUniState_8u* pRndObj;
    int sizeRndObj;

    // get spec size
    ippsRandUniformGetSize_8u(&sizeRndObj);
    pRndObj = (IppsRandUniState_8u*)ippsMalloc_8u(sizeRndObj);
    // initialize rnd spec
    ippsRandUniformInit_8u(pRndObj, 0/*low*/, 255/*high*/, 0/*seed*/);

    // fill image
    for ( i=0; i<HEIGHT; i++ ) {
        sts = ippsRandUniform_8u(pImg + i*WIDTH, WIDTH, pRndObj);
    }
    ippsFree( pRndObj );
}

printf_8u_2D("pImg:", pImg, roi, WIDTH, sts);
{
    const int nBins = 5;
    int nLevels[] = { nBins+1 };
    Ipp32f lowerLevel[] = {0};
    Ipp32f upperLevel[] = {256};
    Ipp32f pLevels[nBins+1], *ppLevels[1];
    int sizeHistObj, sizeBuffer;
    IppiHistogramSpec* pHistObj;
    Ipp8u* pBuffer;
    Ipp32u pHistVec[nBins];

    // get sizes for spec and buffer
    ippiHistogramGetBufferSize(ipp8u, roi, nLevels, 1/*nChan*/, 1/*uniform*/, &sizeHistObj, &sizeBuffer);
    pHistObj = (IppiHistogramSpec*)ippsMalloc_8u(sizeHistObj);
    pBuffer = (Ipp8u*)ippsMalloc_8u(sizeBuffer);
    // initialize spec
    ippiHistogramUniformInit(ipp8u, lowerLevel, upperLevel, nLevels, 1, pHistObj);

    // check levels of bins
    ppLevels[0] = pLevels;
    sts = ippiHistogramGetLevels(pHistObj, ppLevels);
    printf_32f("pLevels:", pLevels, nBins+1, sts);

    // calculate histogram
    sts = ippiHistogram_8u_C1R(pImg, WIDTH, roi, pHistVec, pHistObj, pBuffer);
    ippsFree(pHistObj);
    ippsFree(pBuffer);
}
See Also

Regions of Interest in Intel IPP

Histogram Computes the intensity histogram of an image.

HistogramGetBufferSize Computes the size of the specification structure and work buffer for the ippiHistogram function.

HistogramGetLevels Returns the array with level values stored in the specification structure.

HistogramInit, HistogramUniformInit Initializes the specification structure for the ippiHistogram function.

CountInRange

Computes the number of pixels within the given intensity range.

Syntax

Case 1: Operation on one-channel data

IppStatus ippiCountInRange_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppSize roiSize, int* counts, Ipp<datatype> lowerBound, Ipp<datatype> upperBound);

Supported values for mod:

8u_C1R 32f_C1R

Case 2: Operation on multi-channel data

IppStatus ippiCountInRange_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppSize roiSize, int counts[3], Ipp<datatype> lowerBound[3], Ipp<datatype> upperBound[3]);

Supported values for mod:

8u_C3R 32f_C3R

8u_AC4R 32f_AC4R
Include Files
ippi.h

Domain Dependencies
Headers: ippi.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

\( pSrc \) Pointer to the source image ROI.
\( srcStep \) Distance in bytes between starts of consecutive lines in the source image.
\( roiSize \) Size of the source ROI in pixels.
\( counts \) The computed number of pixels within the given intensity range. An array of 3 values in case of multi-channel data.
\( lowerBound \) Lower limit of the intensity range.
\( upperBound \) Upper limit of the intensity range.

Description
This function operates with ROI (see Regions of Interest in Intel IPP). This function computes the number of pixels in the image which have intensity values in the range between \( lowerBound \) and \( upperBound \) (inclusive).

In case of a multi-channel image, pixels are counted within intensity range for each color channel separately, and the array \( counts \) of three resulting values is returned. The alpha channel values, if present, are not processed.

Return Values

\( ippStsNoErr \) Indicates no error. Any other value indicates an error or a warning.
\( ippStsNullPtrErr \) Indicates an error condition if \( pSrc \) pointer is NULL.
\( ippStsSizeErr \) Indicates an error condition if \( roiSize \) has a field with zero or negative value.
\( ippStsStepErr \) Indicates an error condition if \( srcStep \) has a zero or negative value.
\( ippStsRangeErr \) Indicates an error condition if \( lowerBound \) exceeds \( upperBound \).

BlockMinMax

Finds minimum and maximum values for blocks of an image.
Syntax

IppStatus ippiBlockMinMax_<dataType>_C1R(const Ipp<dataType>* pSrc, int srcStep, IppSize srcSize, Ipp<dataType>* pDstMin, int dstMinStep, Ipp<dataType>* pDstMax, int dstMaxStep, IppSize blockSize, Ipp<dataType>* pGlobalMin, Ipp<dataType>* pGlobalMax);

Supported values for dataType:

  8u   16u   16s   32f

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

  pSrc     Pointer to the source image ROI.
  srcStep  Distance, in bytes, between the starting points of consecutive lines in the source image.
  srcSize  Size, in pixels, of the source image.
  pDstMin  Pointer to the destination image to store minimum values per block.
  dstMinStep  Distance, in bytes, between the starting points of consecutive lines in the pDstMin image.
  pDstMax  Pointer to the destination image to store maximum values per block.
  dstMaxStep  Distance, in bytes, between the starting points of consecutive lines in the pDstMax image.
  blockSize Size, in pixels, of the image block.
  pGlobalMin  Destination pointer to the minimum value for the entire source image.
  pGlobalMax  Destination pointer to the maximum value for the entire source image.

Description

This function operates with ROI.

This function finds minimum and maximum values for blocks of the source image, which are defined by the blockSize parameter. Minimum and maximum values for blocks are stored in the pDstMin and pDstMax images, respectively. Minimum and maximum values for the entire image are stored in the pGlobalMin and pGlobalMax pointers, respectively.

If pDstMin or pDstMax pointer is NULL, the corresponding component (minimum or maximum value) is not calculated.

The size of the pDstMin and pDstMax images is calculated by the following formulae:

- If srcWidth is divisible by blockSize, the destination width is equal to:
  
  \[
  \text{dstWidth} = \frac{\text{srcWidth}}{\text{blockSize}}
  \]
otherwise:
\[ \text{dstWidth} = \frac{\text{srcWidth}}{\text{blockWidth}} + 1 \]

- if \( \text{srcHeight} \) is divisible by \( \text{blockHeight} \), the destination height is equal to:
  \[ \text{dstHeight} = \frac{\text{srcHeight}}{\text{blockHeight}} \]
- otherwise:
  \[ \text{dstHeight} = \frac{\text{srcHeight}}{\text{blockHeight}} + 1 \]

**Return Values**

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error when \( \text{pSrc} \), \( \text{pDstMin} \), and \( \text{pDstMax} \) pointers are NULL.
- **ippStsStepErr**: Indicates an error when:
  - \( \text{srcStep} \) is less than \( \text{srcSize.width} \times \text{<pixelSize>} \)
  - \( \text{dstMinStep or dstMaxStep is less than dstSize.width} \times \text{<pixelSize> } \)
- **ippStsSizeErr**: Indicates an error when \( \text{srcSize} \) or \( \text{blockSize} \) has a zero or negative value.

**See Also**

Regions of Interest in Intel IPP

**Min**

*Computes the minimum of image pixel values.*

**Syntax**

**Case 1: Operation on one-channel data**

\[
\text{IppStatus ippiMin\_<mod>}(\text{const Ipp<datatype>\*} \text{pSrc}, \text{int srcStep}, \text{IppSize roiSize}, \text{Ipp<datatype>\*} \text{pMin});
\]

Supported values for \( \text{mod} \):

- 8u\_C1R
- 16u\_C1R
- 16s\_C1R
- 32f\_C1R

**Case 2: Operation on multi-channel data**

\[
\text{IppStatus ippiMin\_<mod>}(\text{const Ipp<datatype>\*} \text{pSrc}, \text{int srcStep}, \text{IppSize roiSize}, \text{Ipp<datatype>} \text{min[3]});
\]

Supported values for \( \text{mod} \):

- 8u\_C3R
- 16u\_C3R
- 16s\_C3R
- 32f\_C3R
- 8u\_AC4R
- 16u\_AC4R
- 16s\_AC4R
- 32f\_AC4R
IppStatusippiMin_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, Ipp<datatype> min[4]);

Supported values for mod:

8u_C4R 16u_C4R 16s_C4R 32f_C4R

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc Pointer to the source image ROI.
srcStep Distance in bytes between starts of consecutive lines in the source image.
roiSize Size of the source ROI in pixels.
pMin Pointer to the minimum pixel value (for one-channel data).
min Array containing minimum channel values of pixels in the source buffer (for multi-channel data).

Description
This function operates with ROI (see Regions of Interest in Intel IPP). This function computes the minimum pixel value pMin for the source image pSrc. In case of a multi-channel image, the minimum is computed over each channel and stored in the array min.

Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error condition if pSrc or pMin pointer is NULL.
ippStsSizeErr Indicates an error condition if roiSize has a field with zero or negative value.

Example
The code example below demonstrates how to use the functionippiMin.

Ipp8u src[4*1] = { 40, 20, 60, 80 };
IppiSize roiSize = { 4, 1 };
Ipp8u min;
ippiMin_8u_C1R ( src, 4, roiSize, &min );
result: min = 20
MinIndx

Computes the minimum of image pixel values and retrieves the x and y coordinates of pixels with minimal intensity values.

Syntax

Case 1: Operation on one-channel data

IppStatus ippiMinIndx_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, Ipp<datatype>* pMin, int* pIndexX, int* pIndexY);

Supported values for mod:

8u_C1R  16u_C1R  16s_C1R  32f_C1R

Case 2: Operation on multi-channel data

IppStatus ippiMinIndx_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, Ipp<datatype> min[3], int indexX[3], int indexY[3]);

Supported values for mod:

8u_C3R  16u_C3R  16s_C3R  32f_C3R
8u_AC4R  16u_AC4R  16s_AC4R  32f_AC4R

IppStatus ippiMinIndx_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, Ipp<datatype> min[4], int indexX[4], int indexY[4]);

Supported values for mod:

8u_C4R  16u_C4R  16s_C4R  32f_C4R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc

Pointer to the source image ROI.

dstStep

Distance in bytes between starts of consecutive lines in the source image.

roiSize

Size of the source ROI in pixels.

pMin

Pointer to the minimum pixel value (for one-channel data).

min

Array containing minimum color channel values of pixels in the source buffer (for multi-channel data).

pIndexX, pIndexY

Pointers to the x and y coordinates of the pixel with minimum value.
Arrays containing the x and y coordinates of pixels with minimum channel values.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function computes the minimum pixel value \( p_{\min} \) for the source image \( p_{\text{Src}} \). In case of a multi-channel image, the minimum is computed over each channel and stored in the array \( \text{min} \). The function also retrieves the \( x \) and \( y \) coordinates of pixels on which the minimum is reached. If several pixels have equal minimum values, the coordinates of the first pixel from the start of the source buffer is returned. For multi-channel data, \( \text{indexX}[k] \) and \( \text{indexY}[k] \) are the \( x \) and \( y \) coordinates of the pixel that has the minimal intensity value of the \( k \)-th channel, \( k = 1,2,3,4 \).

**Return Values**

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error condition if one of \( p_{\text{Src}}, p_{\min}, p_{\text{IndexX}}, \) or \( p_{\text{IndexY}} \) pointers is NULL.
- ippStsSizeErr: Indicates an error condition if \( \text{roiSize} \) has a field with zero or negative value.

**Max**

*Computes the maximum of image pixel values.*

**Syntax**

**Case 1: Operation on one-channel data**

\[
\text{IppStatus ippiMax}_{<\text{mod}>}(\text{const Ipp<datatype>}* \text{pSrc}, \text{int srcStep}, \text{IppiSize roiSize}, \text{Ipp<datatype>.AC4R} \text{pMax});
\]

Supported values for \( \text{mod} \):

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R

**Case 2: Operation on multi-channel data**

\[
\text{IppStatus ippiMax}_{<\text{mod}>}(\text{const Ipp<datatype>}* \text{pSrc}, \text{int srcStep}, \text{IppiSize roiSize}, \text{Ipp<datatype>.AC4R} \text{max}[3]);
\]

Supported values for \( \text{mod} \):

- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 8u_AC4R
- 16u_AC4R
- 16s_AC4R
- 32f_AC4R

\[
\text{IppStatus ippiMax}_{<\text{mod}>}(\text{const Ipp<datatype>}* \text{pSrc}, \text{int srcStep}, \text{IppiSize roiSize}, \text{Ipp<datatype>.AC4R} \text{max}[4]);
\]

Supported values for \( \text{mod} \):

- 8u_C4R
- 16u_C4R
- 16s_C4R
- 32f_C4R
Include Files
ippi.h

Domain Dependencies
Headers: ippicore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

\begin{align*}
\textit{pSrc} & \quad \text{Pointer to the source image ROI.} \\
\textit{srcStep} & \quad \text{Distance in bytes between starts of consecutive lines in the source image.} \\
\textit{roiSize} & \quad \text{Size of the source ROI in pixels} \\
\textit{pMax} & \quad \text{Pointer to the maximum pixel value (for one-channel data).} \\
\textit{max} & \quad \text{Array containing maximum channel values of pixels in the source buffer (for multi-channel data).}
\end{align*}

Description
This function operates with ROI (see Regions of Interest in Intel IPP). This function computes the maximum pixel value \( \textit{pMax} \) for the source image \( \textit{pSrc} \). In case of a multi-channel image, the maximum is computed over each channel and stored in the array \( \textit{max} \).

Return Values

\begin{align*}
\text{ippStsNoErr} & \quad \text{Indicates no error. Any other value indicates an error or a warning.} \\
\text{ippStsNullPtrErr} & \quad \text{Indicates an error condition if \textit{pSrc} or \textit{pMax} pointer is NULL.} \\
\text{ippStsSizeErr} & \quad \text{Indicates an error condition if \textit{roiSize} has a field with zero or negative value.}
\end{align*}

MaxIndx

\textit{MaxIndx} computes the maximum of image pixel values and retrieves the \( x \) and \( y \) coordinates of pixels with maximal intensity values.

Syntax

Case 1: Operation on one-channel data

\begin{verbatim}
IppStatus ippiMaxIndx_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, Ipp<datatype>* pMax, int* pIndexX, int* pIndexY);
\end{verbatim}

Supported values for \textit{mod}:

\begin{align*}
8u\_C1R & \quad 16u\_C1R & \quad 16s\_C1R & \quad 32f\_C1R
\end{align*}
Case 2: Operation on multi-channel data

IppStatus ippiMaxIndx_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppSize roiSize, Ipp<datatype> max[3], int indexX[3], int indexY[3]);

Supported values for mod:

8u_C3R  16u_C3R  16s_C3R  32f_C3R
8u_AC4R 16u_AC4R 16s_AC4R 32f_AC4R

IppStatus ippiMaxIndx_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppSize roiSize, Ipp<datatype> max[4], int indexX[4], int indexY[4]);

Supported values for mod:

8u_C4R  16s_C4R  16u_C4R  32f_C4R

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc Pointer to the source image ROI.
srcStep Distance in bytes between starts of consecutive lines in the source image.
roiSize Size of the source ROI in pixels.
pMax Pointer to the maximum pixel value (for one-channel data).
max Array containing maximum channel values of pixels in the source buffer (for multi-channel data).
pIndexX, pIndexY Pointers to the x and y coordinates of the pixel with maximum value.
indexX, indexY Arrays containing the x and y coordinates of pixels with maximum channel values.

Description

This function operates with ROI (see Regions of Interest in Intel IPP). This function computes the maximum pixel value pMax for the source image pSrc. In case of a multi-channel image, the maximum is computed over each channel and stored in the array max. The function also retrieves the x and y coordinates of pixels on which the maximum is reached. If several pixels have equal maximum values, the coordinates of the first pixel from the start of the source buffer is returned. For multi-channel data, indexX[k] and indexY[k] are the x and y coordinates of the pixel that has the maximal intensity value of the k-th channel, k = 1,2,3,4.

Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
Indicates an error condition if any of pSrc, pMax, pIndexX, or pIndexY pointers is NULL.

Indicates an error condition if roiSize has a field with zero or negative value.

**Example**

The code example below demonstrates how to use the function ippiMaxIndx.

```c
Ipp8u src[4*1] = { 40, 20, 60, 80 };
IppSize roiSize = { 4, 1 };
Ipp8u max;
int IndexX;
int IndexY;

ippiMaxIndx_8u_C1R ( src, 4, roiSize, &max, &IndexX, &IndexY );

result: max = 80  IndexX = 3 IndexY = 0
```

**MinMax**

*Computes the minimum and maximum of image pixel values.*

**Syntax**

**Case 1: Operation on one-channel data**

```
IppStatus ippiMinMax_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppSize roiSize,
Ipp<datatype>* pMin, Ipp<datatype>* pMax);
```

Supported values for `mod`:

- `8u_C1R`
- `16u_C1R`
- `16s_C1R`
- `32f_C1R`

**Case 2: Operation on multi-channel data**

```
IppStatus ippiMinMax_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppSize roiSize,
Ipp<datatype> min[3], Ipp<datatype> max[3]);
```

Supported values for `mod`:

- `8u_C3R`
- `16u_C3R`
- `16s_C3R`
- `32f_C3R`
- `8u_AC4R`
- `16u_AC4R`
- `16s_AC4R`
- `32f_AC4R`

IppStatus ippiMinMax_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppSize roiSize,
Ipp<datatype> min[4], Ipp<datatype> max[4]);

Supported values for `mod`:

- `8u_C4R`
- `16u_C4R`
- `16s_C4R`
- `32f_C4R`
Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc**
  Pointer to the source image ROI.

- **srcStep**
  Distance in bytes between starts of consecutive lines in the source image.

- **roiSize**
  Size of the source ROI in pixels.

- **pMin, pMax**
  Pointers to the minimum and maximum pixel values (for one-channel data).

- **min, max**
  Arrays containing minimum and maximum channel values of pixels in the source buffer (for multi-channel data).

Description
This function operates with ROI (see Regions of Interest in Intel IPP). This function computes the minimum and maximum pixel values \( p_{\text{Min}} \) and \( p_{\text{Max}} \) for the source image \( p_{\text{Src}} \). In case of a multi-channel image, the minimum and maximum is computed over each channel and stored in the arrays \( \text{min} \) and \( \text{max} \).

Return Values

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**
  Indicates an error condition if \( p_{\text{Src}}, p_{\text{Min}}, \) or \( p_{\text{Max}} \) pointer is NULL.

- **ippStsSizeErr**
  Indicates an error condition if \( \text{roiSize} \) has a field with zero or negative value.

**MinMaxIndx**

*Calculates minimum and maximum pixel values and their indexes in selected image rectangle.*

Syntax

**Case 1: Operation on one-channel data**

\[
\text{IppStatus ippiMinMaxIndx}_{\text{<mod>}}(\text{const Ipp<datatype>* } p_{\text{Src}}, \text{ int } \text{srcStep}, \text{ IppSize roiSize}, \text{ Ipp32f* } p_{\text{MinVal}}, \text{ Ipp32f* } p_{\text{MaxVal}}, \text{ IppiPoint* } p_{\text{MinIndex}}, \text{ IppiPoint* } p_{\text{MaxIndex}});
\]

Supported values for **mod**:

- 8u_C1R
- 16u_C1R
- 32f_C1R
**Case 2: Masked operation on one-channel data**

```c
IppStatus ippiMinMaxIndx_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp8u* pMask, int maskStep, IppiSize roiSize, Ipp32f* pMinVal, Ipp32f* pMaxVal, IppiPoint* pMinIndex, IppiPoint* pMaxIndex);
```

Supported values for `mod`:

- 8u_C1MR
- 16u_C1MR
- 32f_C1MR

**Case 3: Operation on multi-channel data**

```c
IppStatus ippiMinMaxIndx_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, int coi, Ipp32f* pMinVal, Ipp32f* pMaxVal, IppiPoint* pMinIndex, IppiPoint* pMaxIndex);
```

Supported values for `mod`:

- 8u_C3CR
- 16u_C3CR
- 32f_C3CR

**Case 4: Masked operation on multi-channel data**

```c
IppStatus ippiMinMaxIndx_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp8u* pMask, int maskStep, IppiSize roiSize, int coi, Ipp32f* pMinVal, Ipp32f* pMaxVal, IppiPoint* pMinIndex, IppiPoint* pMaxIndex);
```

Supported values for `mod`:

- 8u_C3CMR
- 16u_C3CMR
- 32f_C3CMR

**Include Files**

ippcv.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

**Parameters**

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pMask**: Pointer to the mask image.
- **maskStep**: Distance in bytes between starts of consecutive lines in the mask image.
- **roiSize**: Size of the image ROI in pixels.
- **coi**: Channel of interest (for color images only); can be 1, 2, or 3.
- **pMinVal**: Pointer to the variable that returns the value of the minimum pixel.
- **pMaxVal**: Pointer to the variable that returns the value of the maximum pixel.
Description
This function operates with ROI (see Regions of Interest in Intel IPP). This function finds minimum and maximum pixel values and their indexes in an image ROI or in an arbitrary image region defined by nonzero mask values. If there are several minima and maxima in the selected area, the function returns the top leftmost positions. If the specified region in the mask mode is empty, that is, the mask image is filled with zeros, then the function returns \( \{minIndex, maxIndex\} = \{0, 0\} \), \( minVal= maxVal= 0 \). If any of the parameters \( pMinVal, pMaxVal, pMinIndex, \) or \( pMaxIndex \) is not required, the zero pointer is to be passed to the corresponding parameter.

Return Values
- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**
  Indicates an error condition if \( pSrc \) or \( pMask \) pointer is NULL.
- **ippStsSizeErr**
  Indicates an error condition if \( roiSize \) has a field with zero or negative value.
- **ippStsStepErr**
  Indicates an error for masked operations when \( srcStep \) or \( maskStep \) is less than \( roiSize.width * \) pixelSize.
- **ippStsNotEvenStepErr**
  Indicates an error when steps for floating-point images cannot be divided by 4.
- **ippStsCOIErr**
  Indicates an error when \( coi \) is not 1, 2, or 3.

MaxEvery

Computes maximum value for each pair of pixels of two images.

Syntax
Case 1: Not-in-place operation

IppStatus ippiMaxEvery_8u_C1R(const Ipp8u* pSrc1, int src1Step, const Ipp8u* pSrc2, int src2Step, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiMaxEvery_16u_C1R(const Ipp16u* pSrc1, int src1Step, const Ipp16u* pSrc2, int src2Step, Ipp16u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiMaxEvery_32f_C1R(const Ipp32f* pSrc1, int src1Step, const Ipp32f* pSrc2, int src2Step, Ipp32f* pDst, int dstStep, IppiSize roiSize);

Case 2: In-place operation

IppStatus ippiMaxEvery_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pSrcDst, int srcDStep, IppiSize roiSize);

Supported values for \( mod \):

- 8u_C1IR
- 16u_C1IR
- 16s_C1IR
- 32f_C1IR
Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc1, pSrc2**
  Pointer to the first and second source image, respectively (for not-in-place operation).

- **src1Step, src2Step**
  Distance, in bytes, between the starting points of consecutive lines in the first and second source image, respectively (for not-in-place operation).

- **pDst**
  Pointer to the destination image (for not-in-place operation).

- **pSrc**
  Pointer to the first source image ROI (for in-place operation).

- **srcStep**
  Distance, in bytes, between the starting points of consecutive lines in the first source image (for in-place operation).

- **dstStep**
  Distance, in bytes, between the starting points of consecutive lines in the destination image.

- **pSrcDst**
  Pointer to the second source and destination image ROI (for in-place operation).

- **srcDstStep**
  Distance, in bytes, between the starting points of consecutive lines in the second source and destination image (for in-place operation).

- **roiSize**
  Size of the image ROI in pixels.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

**Not-in-place operation:**

This function computes the maximum value for each pair of the corresponding pixels of two source images (pSrc1 and pSrc2 for not-in-place operation or pSrc and pSrcDst for in-place), and stores the result in pDst.

**In-place operation:**

This function computes the maximum value for each pair of the corresponding pixels of two source images pSrc and pSrcDst, and stores the result in pSrcDst:

\[ pSrcDst(i, j) = \max(pSrc(i, j), pSrcDst(i, j)) \]

Return Values

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.
Indicates an error condition if one of the specified pointers is NULL.

Indicates an error condition if `roiSize` has a field with zero or negative value.

Indicates an error condition if `srcStep`, `src1Step`, `src2Step` or `srcDstStep` is less than `roiSize.width`*<pixelSize>.

Indicates an error condition if one of step values for floating-point images are not divisible by 4.

---

### MinEvery

**Computes minimum value for each pair of pixels of two images.**

#### Syntax

**Case 1: Not-in-place operation**

```c
IppStatus ippiMinEvery_8u_C1R(const Ipp8u* pSrc1, int src1Step, const Ipp8u* pSrc2, int src2Step, Ipp8u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiMinEvery_16u_C1R(const Ipp16u* pSrc1, int src1Step, const Ipp16u* pSrc2, int src2Step, Ipp16u* pDst, int dstStep, IppiSize roiSize);
IppStatus ippiMinEvery_32f_C1R(const Ipp32f* pSrc1, int src1Step, const Ipp32f* pSrc2, int src2Step, Ipp32f* pDst, int dstStep, IppiSize roiSize);
```

**Case 2: In-place operation**

```c
IppStatus ippiMinEvery_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize);
```

**Supported values for** `mod`:

<table>
<thead>
<tr>
<th>8u_C1IR</th>
<th>16u_C1IR</th>
<th>16s_C1IR</th>
<th>32f_C1IR</th>
</tr>
</thead>
<tbody>
<tr>
<td>8u_C3IR</td>
<td>16u_C3IR</td>
<td>16s_C3IR</td>
<td>32f_C3IR</td>
</tr>
<tr>
<td>8u_C4IR</td>
<td>16u_C4IR</td>
<td>16s_C4IR</td>
<td>32f_C4IR</td>
</tr>
<tr>
<td>8u_AC4IR</td>
<td>16u_AC4IR</td>
<td>16s_AC4IR</td>
<td>32f_AC4IR</td>
</tr>
</tbody>
</table>

#### Include Files

ippi.h

#### Domain Dependencies

**Headers:** ippcore.h, ippvm.h, ipps.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib

#### Parameters

- `pSrc1`, `pSrc2`  
  Pointer to the first and second source image, respectively (for not-in-place operation).
**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

**Not-in-place operation:**

This function computes the minimum value for each pair of the corresponding pixels of two source images \((pSrc1\text{ and } pSrc2\) for not-in-place operation or \(pSrc\text{ and } pSrcDst\) for in-place), and stores the result in \(pDst\).

**In-place operation:**

This function computes the minimum value for each pair of the corresponding pixels of two source images \(pSrc\text{ and } pSrcDst\), and stores the result in \(pSrcDst\):

\[
pSrcDst(i, j) = \min(pSrc(i, j), pSrcDst(i, j)).
\]

**Return Values**

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error condition if one of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error condition if roiSize has a field with zero or negative value.
- ippStsStepErr: Indicates an error condition if srcStep, src1Step, src2Step or srcDstStep is less than roiSize.width*<pixelSize>.
- ippStsNotEvenStepErr: Indicates an error condition if one of step values for floating-point images are not divisible by 4.

**FindPeaks3x3GetBufferSize**

*Computes the size of the working buffer for the peak search.*

**Syntax**

```c
IppStatus ippiFindPeaks3x3GetBufferSize_32s_C1R(int roiWidth, int* pBufferSize);
```
IppStatus ippiFindPeaks3x3GetBufferSize_32f_C1R(int roiWidth, int* pBufferSize);

**Include Files**
ippcv.h

**Domain Dependencies**
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **roiWidth**: Maximum width of the image, in pixels.
- **pBufferSize**: Pointer to the size of the working buffer.

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP).
This function computes the size of the working buffer required for the function ippiFindPeaks3x3. The buffer with the length pBufferSize[0] can be used to filter images with width that is less than or equal to roiWidth.

Example 11-8 shows how to use the function ippiFindPeaks3x3GetBufferSize_32f_C1R.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if the pointer pBufferSize is NULL.
- **ippStsSizeErr**: Indicates an error condition if roiWidth is less than 1.

**FindPeaks3x3**

*Finds coordinates of peaks (maximums or minimums) with absolute value exceeding threshold value.*

**Syntax**

IppStatus ippiFindPeaks3x3_32s_C1R(const Ipp32s* pSrc, int srcStep, IppiSize roiSize, Ipp32s threshold, IppiPoint* pPeak, int maxPeakCount, int* pPeakCount, IppiNorm norm, int border, Ipp8u* pBuffer);

IppStatus ippiFindPeaks3x3_32f_C1R(const Ipp32f* pSrc, int srcStep, IppiSize roiSize, Ipp32f threshold, IppiPoint* pPeak, int maxPeakCount, int* pPeakCount, IppiNorm norm, int border, Ipp8u* pBuffer);

**Include Files**
ippcv.h

**Domain Dependencies**
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Parameters

pSrc  
Pointer to the first source image ROI.

srcStep  
Distance in bytes between starts of consecutive lines in the first source image.

roiSize  
Size of the image ROI in pixels.

threshold  
Threshold value.

pPeak  
Pointer to the coordinates peaks [maxPeakCount].

maxPeakCount  
Maximum number of peaks.

detected peaks.

pPeakCount  
Pointer to the number of the detected peaks.

border  
Border value, only pixel with distance from the edge of the image greater than border are processed.

norm  
Specifies type of the norm to form the mask for extremum search:

ippiNormInf  
Infinity norm (8-connectivity, 3x3 rectangular mask);

ippiNormL1  
L1 norm (4-connectivity, 3x3 cross mask).

pBuffer  
Pointer to the working buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function detects local maximum and minimum pixels in the source image:

\[ p_{Src}(i_m, j_m) = \max_{(k, l) \in \mathcal{O}(i_m, j_m)} p_{Src}(k, l), \quad p_{Src}(i_m, j_m) \geq \text{threshold} \]

\[ p_{Src}(i_m, j_m) = \min_{(k, l) \in \mathcal{O}(i_m, j_m)} p_{Src}(k, l), \quad |p_{Src}(i_m, j_m)| \geq \text{threshold} \]

and stores their coordinates in the pPeak array pPeak[m].x = jm, pPeak[m].y = im, m = 0, ..., pPeakCount[0], pPeakCount[0] ≤ maxPeakCount

The neighborhood \( \mathcal{O}(i, j) \) for the extremum search is defined by the parameter norm. The number of detected extremums is returned in pPeakCount[0]. The operation is stopped when the maxPeakCount extremums are found.

The function requires the working buffer pBuffer whose size should be computed by the functionippiFindPeaks3x3GetBufferSize beforehand.

Return Values

ippStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  
Indicates an error condition if one of the specified pointers is NULL.
Image Moments

Spatial and central moments are important statistical properties of an image. The spatial moment \( M_U(m, n) \) of order \((m, n)\) is defined as follows:

\[
M_U(m, n) = \sum_{j}^{\text{rows}} \sum_{k}^{\text{columns}} x_k^m y_j^n P_{j,k}
\]

where the summation is performed for all rows and columns in the image; \( P_{j,k} \) are pixel values; \( x_k \) and \( y_j \) are pixel coordinates; \( m \) and \( n \) are integer power exponents that define the moment order.

The central moment \( U_U(m, n) \) is the spatial moment computed relative to the “center of gravity” \((x_0, y_0)\):

\[
U_U(m, n) = \sum_{j}^{\text{rows}} \sum_{k}^{\text{columns}} (x_k-x_0)^m (y_j-y_0)^n P_{j,k}
\]

where \( x_0 = M_U(1,0)/ M_U(0,0) \) and \( y_0 = M_U(0,1)/ M_U(0,0) \).

The normalized spatial moment \( M(m, n) \) and central moment \( U(m, n) \) are defined as follows:

\[
M(m, n) = \frac{M_U(m, n)}{M_U(0,0)^{m+n+2}}
\]

\[
U(m, n) = \frac{U_U(m, n)}{U_U(0,0)^{m+n+2}}
\]

The Intel IPP functions support moments of order \((m, n)\) with \(0 \leq m + n \leq 3\). The computation of seven invariant Hu moments derived from the second and third order moments is also supported. All computed moments are stored in context structures of type \text{IppiMomentState}_64s (for integer versions) or \text{IppiMomentState}_64f (for floating point versions).

Most Intel IPP functions for computing image moments have code branches that implement different algorithms to compute the results. You can choose the desired code variety to be used by the given function by setting the \text{hint} argument to one of the following values that are listed in Table "Hint Arguments for Image Moment Functions":

Example

To better understand usage of this function, refer to the FindPeaks3x3.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.
### Hint Arguments for Image Moment Functions

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippAlgHintNone</td>
<td>The computation algorithm will be chosen by the internal function logic.</td>
</tr>
<tr>
<td>ippAlgHintFast</td>
<td>Fast algorithm must be used. The output results will be less accurate.</td>
</tr>
<tr>
<td>ippAlgHintAccurate</td>
<td>High accuracy algorithm must be used. The function will need more time to execute.</td>
</tr>
</tbody>
</table>

### MomentGetStateSize

*Computes the size of the external buffer for the moment context structure.*

**Syntax**

```c
IppStatus ippiMomentGetStateSize_64f(IppHintAlgorithm hint, int* pSize);
```

**Include Files**

ippi.h

**Domain Dependencies**

- **Headers:** ippcore.h, ippvm.h, ipps.h
- **Libraries:** ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- `pSize`  
  Pointer to the computed value of the buffer size.

- `hint`  
  Option to select the algorithmic implementation of the function.

**Description**

Use this function to determine the size of the external work buffer for the moment context structure to be initialized by the function `ippiMomentInit`. Computation algorithm is specified by `hint` argument (see Table "Hint Arguments for Image Moment Functions").

**Return Values**

- `ippStsNoErr`  
  Indicates no error. Any other value indicates an error or a warning.

- `ippStsNullPtrErr`  
  Indicates an error condition if `pSize` pointer is NULL.

### MomentInit

*Initializes the moment context structure.*

**Syntax**

```c
IppStatus ippiMomentInit_64f(IppiMomentState_64f* pState, IppHintAlgorithm hint);
```

**Include Files**

ippi.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pState  
Pointer to the structure for storing moment values.

hint  
Option to select the algorithmic implementation of the function.

Description

This function initializes the structure that is needed for the function ippiMoments to store the computed image moments. Computation algorithm is specified by hint argument (see Table "Hint Arguments for Image Moment Functions").

The structure is allocated in the external buffer. The size of this buffer can be computed by the function ippiMomentGetStateSize.

Return Values

ippiStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippiStsNullPtrErr  
Indicates an error condition if pState pointer is NULL.

Moments

*Computes all image moments of order 0 to 3 and Hu moment invariants.*

Syntax

Case 1: Computation of floating-point results

IppStatus ippiMoments64f_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, IppiMomentState_64f* pCtx);

Supported values for mod:

- 8u_C1R
- 16u_C1R
- 32f_C1R
- 8u_C3R
- 16u_C3R
- 32f_C3R
- 8u_AC4R
- 16u_AC4R
- 32f_AC4R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

*pSrc*  
Pointer to the source image ROI.

*srcStep*  
Distance in bytes between starts of consecutive lines in the source image.

*roiSize*  
Size of the source ROI in pixels.

*pCtx*  
Pointer to the structure that stores image moments.

Description

This function operates with ROI (see Regions of Interest in Intel IPP). This function computes all spatial and central moments of order 0 to 3 for the source image *pSrc*. The seven Hu moment invariants are also computed. Different functions, *ippiMoments64s* and *ippiMoments64f*, are used to compute image moments in integer and floating-point formats, respectively.

The *ippiMoments* function computes spatial moment values relative to the image point referred to by *pSrc*. Note that this point is the ROI origin and may not coincide with the entire image origin. If you need to obtain spatial moment values relative to the actual image origin, use *ippiGetSpatialMoment* functions to recalculate them.

The moments’ values are stored in the *pCtx* structure. To retrieve a particular moment value, use one of the functions described in the sections that follow.

Return Values

*ippStsNoErr*  
Indicates no error. Any other value indicates an error or a warning.

*ippStsNullPtrErr*  
Indicates an error condition if *pSrc* or *pCtx* pointer is NULL.

*ippStsSizeErr*  
Indicates an error condition if *roiSize* has a field with zero or negative value.

*ippStsStepErr*  
Indicates an error condition if *srcStep* has a zero or negative value.

*ippStsContextMatchErr*  
Indicates an error condition if a pointer to an invalid structure is passed.

GetSpatialMoment

*Retrieves image spatial moment of the specified order, computed by* *ippiMoments.*

Syntax

```c
IppStatus ippiGetSpatialMoment_64f(const IppiMomentState_64f* pState, int mOrd, int nOrd, int nChannel, IppiPoint roiOffset, Ipp64f* pValue);
```

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib
**Parameters**

- **pState**: Pointer to the structure that stores image moments.
- **mOrd, nOrd**: Integer power exponents defining the moment order. These arguments must satisfy the condition $0 \leq m\text{Ord} + n\text{Ord} \leq 3$.
- **nChannel**: The channel for which the moment is returned.
- **roiOffset**: Offset in pixels of the ROI origin (top left corner) from the image origin.
- **pValue**: Pointer to the retrieved moment value.

**Description**

This function returns the pointer `pValue` to the spatial moment that was previously computed by the `ippiMoments` function. All spatial moment values are computed by `ippiMoments` relative to the image ROI origin. You may also obtain spatial moment values relative to different point in the image, using the appropriate `roiOffset` settings.

The moment order is specified by the integer exponents `mOrd, nOrd`.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if `pState` or `pValue` pointer is NULL.
- **ippStsContextMatchErr**: Indicates an error condition if a pointer to an invalid structure is passed.
- **ippStsSizeErr**: Indicates an error condition if $m\text{Ord} + n\text{Ord}$ is greater than 3, or `nChannel` has an illegal value.

**GetCentralMoment**

*Retrieves image central moment computed by `ippiMoments`.*

**Syntax**

```c
IppStatus ippiGetCentralMoment_64f(const IppiMomentState_64f* pState, int mOrd, int nOrd, int nChannel, Ipp64f* pValue);
```

**Include Files**

`ippi.h`

**Domain Dependencies**

- **Headers**: `ippcore.h`, `ippvm.h`, `ipps.h`
- **Libraries**: `ippcore.lib`, `ippvm.lib`, `ipps.lib`

**Parameters**

- **pState**: The structure that stores image moments.
- **mOrd, nOrd**: Integer power exponents defining the moment order. These arguments must satisfy the condition $0 \leq m\text{Ord} + n\text{Ord} \leq 3$. 
nChannel

The channel for which the moment is returned.

pValue

Pointer to the returned moment value.

Description

This function returns the pointer pValue to the central moment previously computed by the ippiMoments function. The moment order is specified by the integer exponents mOrd, nOrd.

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr

Indicates an error condition if pState or pValue pointer is NULL.

ippStsContextMatchErr

Indicates an error condition if a pointer to an invalid structure is passed.

ippStsSizeErr

Indicates an error condition if mOrd + nOrd is greater than 3, or nChannel has an illegal value.

GetNormalizedSpatialMoment

Retrieves the normalized value of the image spatial moment computed by ippiMoments.

Syntax

IppStatus ippiGetNormalizedSpatialMoment_64f(const IppiMomentState_64f* pState, int mOrd, int nOrd, int nChannel, IppiPoint roiOffset, Ipp64f* pValue);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pState

The structure that stores image moments.

mOrd, nOrd

Integer power exponents defining the moment order. These arguments must satisfy the condition 0 ≤ mOrd + nOrd ≤ 3.

nChannel

The channel for which the moment is returned.

roiOffset

Offset in pixels of the ROI origin (top left corner) from the image origin.

pValue

Pointer to the returned normalized moment value.

Description

This function normalizes the spatial moment value that was previously computed by the ippiMoments function, and returns the pointer pValue to the normalized moment. See Image Moments for details of moments normalization. The moment order (mOrd, nOrd) is specified by integer power exponents. All
spatial moment values are computed by `ippiMoments` relative to the image ROI origin. You may also obtain normalized spatial moment values relative to different point in the image, using the appropriate `roiOffset` settings.

**Return Values**

- `ippStsNoErr` indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr` indicates an error condition if `pState` or `pValue` pointer is NULL.
- `ippStsContextMatchErr` indicates an error condition if a pointer to an invalid structure is passed.
- `ippStsMoment00ZeroErr` indicates an error condition if $M(0,0)$ value is close to zero.
- `ippStsSizeErr` indicates an error condition if $mOrd + nOrd$ is greater than 3, or $nChannel$ has an illegal value.

### GetNormalizedCentralMoment

Retrieves the normalized value of the image central moment computed by `ippiMoments`.

**Syntax**

```c
IppStatus ippiGetNormalizedCentralMoment_64f(const IppiMomentState_64f* pState, int mOrd, int nOrd, int nChannel, Ipp64f* pValue);
```

**Include Files**

`ippi.h`

**Domain Dependencies**

Headers: `ippcore.h`, `ippvm.h`, `ipps.h`

Libraries: `ippcore.lib`, `ippvm.lib`, `ipps.lib`

**Parameters**

- `pState` The structure that stores image moments.
- `mOrd`, `nOrd` Integer power exponents defining the moment order. These arguments must satisfy the condition $0 \leq mOrd + nOrd \leq 3$.
- `nChannel` The channel for which the moment is returned.
- `pValue` Pointer to the returned moment value.

**Description**

This function normalizes the central moment value that was previously computed by the `ippiMoments` function, and returns the pointer `pValue` to the normalized moment. The moment order $(mOrd, nOrd)$ is specified by the integer power exponents. See Image Moments for details of moments normalization.

**Return Values**

- `ippStsNoErr` indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr` indicates an error condition if `pState` or `pValue` pointer is NULL.
GetHuMoments
Retrieves image Hu moment invariants computed by ippiMoments function.

Syntax
IppStatus ippiGetHuMoments_64f(const IppiMomentState_64f* pState, int nChannel, IppiHuMoment_64f pHm);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pState Pointer to the structure that stores image moments.
nChannel The channel for which the moment is returned.
pHm Pointer to the array containing the Hu moment invariants.

Description
This function returns the pointer pHm to the array of seven Hu moment invariants previously computed by the ippiMoments function.

Return Values
ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error condition if pState or pHm pointer is NULL.
ippStsContextMatchErr Indicates an error condition if a pointer to an invalid structure is passed.
ippStsMoment00ZeroErr Indicates an error condition if M(0,0) value is close to zero.

Example
To better understand usage of this function, refer to the GetHuMoments.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

Image Norms
The functions described in this section compute the following norms of the image pixel values:
- Infinity norm (the largest absolute pixel value)
• L1 norm (the sum of absolute pixel values)
• L2 norm (the square root of the sum of squared pixel values).

Functions of this group also help you compute the norm of differences in pixel values of two input images as well as the relative error for two input images.

**Norm_Inf**

*Computes the infinity norm of image pixel values.*

**Syntax**

**Case 1: Operation on one-channel data**

```c
IppStatus ippiNorm_Inf_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, Ipp64f* pValue);
```

Supported values for `mod`:

- `8u_C1R`
- `16u_C1R`
- `16s_C1R`
- `32f_C1R`

**Case 2: Masked operation on one-channel data**

```c
IppStatus ippiNorm_Inf_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp8u* pMask, int maskStep, IppiSize roiSize, Ipp64f* pNorm);
```

Supported values for `mod`:

- `8u_C1MR`
- `16u_C1MR`
- `32f_C1MR`

**Case 3: Operation on multi-channel data**

```c
IppStatus ippiNorm_Inf_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, Ipp64f value[3]);
```

Supported values for `mod`:

- `8u_C3R`
- `16u_C3R`
- `16s_C3R`
- `32f_C3R`

```c
IppStatus ippiNorm_Inf_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, Ipp64f value[4]);
```

Supported values for `mod`:

- `8u_C4R`
- `16u_C4R`
- `16s_C4R`
- `32f_C4R`

**Case 4: Masked operation on multi-channel data**

```c
IppStatus ippiNorm_Inf_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp8u* pMask, int maskStep, IppiSize roiSize, int coi, Ipp64f* pNorm);
```

Supported values for `mod`:

- `8u_C3CMR`
- `16u_C3CMR`
- `32f_C3CMR`

**Include Files**

ippcv.h
ippi.h

**Domain Dependencies**

Flavors declared in ippcv.h:
- **Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h
- **Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Flavors declared in ippi.h:
- **Headers:** ippcore.h, ippvm.h, ipps.h
- **Libraries:** ippcore.lib, ippvm.lib,ipps.lib

**Parameters**

- **pSrc**
  Pointer to the source image ROI.
- **srcStep**
  Distance in bytes between starts of consecutive lines in the source image.
- **pMask**
  Pointer to the mask image.
- **maskStep**
  Distance in bytes between starts of consecutive lines in the mask image.
- **roiSize**
  Size of the source ROI in pixels.
- **coi**
  Channel of interest (for color images only); can be 1, 2, or 3.
- **pValue**
  Pointer to the computed infinity norm of pixel values.
- **value**
  An array containing the computed infinity norms of channel values in case of multi-channel data.
- **pNorm**
  Pointer to the computed norm value in the mask mode.

**Description**

The flavors of the function ippiNorm_Inf that perform masked operation are declared in the ippcv.h file. All other function flavors are declared in the ippi.h file. This function operates with ROI (see Regions of Interest in Intel IPP) and computes the infinity norm `pValue` (pNorm for the mask mode) for the source image pSrc. This norm is defined as the largest absolute pixel value in an image. In the mask mode, the computation is done over pixels selected by non-zero mask values.

For non-masked operations on a multi-channel image (Case 3), the norm is computed separately for each channel and stored in the array value.

In the mask multi-channel mode (Case 4), the norm is computed for a single channel of interest specified by coi.

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**
  Indicates an error when any of the specified pointers is NULL.
- **ippStsSizeErr**
  Indicates an error condition if roiSize has a field with zero or negative value.
- **ippStsStepErr**
  Indicates an error condition in mask mode, if srcStep or maskStep is less than roiSize.width * <pixelSize>.
Indicates an error condition in mask mode if steps for floating-point images cannot be divided by 4.

Indicates an error when coi is not 1, 2, or 3.

**Norm_L1**

*Computes the L1-norm of image pixel values.*

**Syntax**

**Case 1: Operation on one-channel integer data**

```c
IppStatusippiNorm_L1_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, Ipp64f* pValue);
```

Supported values for `mod`:

- 8u_C1R
- 16u_C1R
- 16s_C1R

**Case 2: Operation on one-channel floating-point data**

```c
IppStatusippiNorm_L1_32f_C1R(const Ipp32f* pSrc, int srcStep, IppiSize roiSize, Ipp64f* pValue, IppHintAlgorithm hint);
```

**Case 3: Masked operation on one-channel data**

```c
IppStatusippiNorm_L1_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp8u* pMask, int maskStep, IppiSize roiSize, Ipp64f* pNorm);
```

Supported values for `mod`:

- 8u_C1MR
- 16u_C1MR
- 32f_C1MR

**Case 4: Operation on multi-channel integer data**

```c
IppStatusippiNorm_L1_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, Ipp64f value[3]);
```

Supported values for `mod`:

- 8u_C3R
- 16u_C3R
- 16s_C3R

```c
IppStatusippiNorm_L1_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, Ipp64f value[4]);
```

Supported values for `mod`:

- 8u_C4R
- 16u_C4R
- 16s_C4R

**Case 5: Operation on multi-channel floating-point data**

```c
IppStatusippiNorm_L1_32f_C3R(const Ipp32f* pSrc, int srcStep, IppiSize roiSize, Ipp64f value[3], IppHintAlgorithm hint);
```

```c
IppStatusippiNorm_L1_32f_C4R(const Ipp32f* pSrc, int srcStep, IppiSize roiSize, Ipp64f value[4], IppHintAlgorithm hint);
```

---

703
Case 6: Masked operation on multi-channel data

IppStatusippiNorm_L1_<mod>(const Ipp<datatype>* pSrc, int srcStep, const Ipp8u* pMask, int maskStep, IppiSize roiSize, int coi, Ipp64f* pNorm);

Supported values for mod:

8u_C3CMR  16u_C3CMR  32f_C3CMR

Include Files

ippcv.h
ippi.h

Domain Dependencies

Flavors declared in ippcv.h:
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Flavors declared in ippi.h:
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc Pointer to the source image ROI.
srcStep Distance in bytes between starts of consecutive lines in the source image.
pMask Pointer to the mask image.
maskStep Distance in bytes between starts of consecutive lines in the mask image.
roiSize Size of the source ROI in pixels.
coi Channel of interest (for color images only); can be 1, 2, or 3.
pValue Pointer to the computed L1- norm of pixel values.
value An array containing the computed L1- norms of channel values in case of multi-channel data.
pNorm Pointer to the computed norm value in the mask mode.
hint Option to select the algorithmic implementation of the function.

Description

The flavors of the function ippiNorm_L1 that perform masked operation are declared in the ippcv.h file. All other function flavors are declared in the ippi.h file. The function operates with ROI (see Regions of Interest in Intel IPP). It computes the L1- norm pValue (pNorm in mask mode) for the source image pSrc. This norm is defined as the sum of absolute pixel values in an image. Computation algorithm is specified by the hint argument (see Table “Hint Arguments for Image Moment Functions”). In the mask mode, the computation is done over pixels selected by nonzero mask values.

For non-masked operations on a multi-channel image (Case 4, 5), the norm is computed separately for each channel and stored in the array value.
In the mask multi-channel mode (Case 6), the norm is computed for a single channel of interest specified by \textit{coi}.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when any of the specified pointers is \texttt{NULL}.
- **ippStsSizeErr**: Indicates an error condition if \textit{roiSize} has a field with zero or negative value.
- **ippStsStepErr**: Indicates an error condition in mask mode, if \textit{srcStep} or \textit{maskStep} is less than \textit{roiSize.width} * \textit{pixelSize}.
- **ippStsNotEvenStepErr**: Indicates an error condition in mask mode if steps for floating-point images cannot be divided by 4.
- **ippStsCOIErr**: Indicates an error when \textit{coi} is not 1, 2, or 3.

**Example**

The code example below demonstrates how an image norm can be computed.

```c
IppStatus norm( void ){
    Ipp64f sum, normL1;
    Ipp8u x[5*4];
    IppiSize roi = {5,4};
    ippSet_8u_C1R( 1, x, 5, roi );
    ippiSum_8u_C1R( x, 5, roi, &sum);
    return ippiNorm_L1_8u_C1R( x, 5, roi, &normL1 );
}
```

**Norm L2**

*Computes the L2- norm of image pixel values.*

**Syntax**

**Case 1: Operation on one-channel integer data**

```c
IppStatus ippiNorm_L2_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize roiSize, Ipp64f* pValue);
```

Supported values for \textit{mod}:

- \texttt{8u\_C1R}
- \texttt{16u\_C1R}
- \texttt{16s\_C1R}

**Case 2: Operation on one-channel floating-point data**

```c
IppStatus ippiNorm_L2_32f_C1R(const Ipp32f* pSrc, int srcStep, IppiSize roiSize, Ipp64f* pValue, IppHintAlgorithm hint);
```
Case 3: Masked operation on one-channel data

IppStatus ippiNorm_L2_\text{<mod>}(\text{const Ipp}<\text{datatype}^{*} \text{pSrc}, \text{int srcStep}, \text{const Ipp8u}^{*} \text{pMask}, \text{int maskStep}, \text{IppiSize roiSize}, \text{Ipp64f}^{*} \text{pNorm});

Supported values for \text{mod}:

8u\text{C1MR} \quad 16u\text{C1MR} \quad 32f\text{C1MR}

Case 4: Operation on multi-channel integer data

IppStatus ippiNorm_L2_\text{<mod>}(\text{const Ipp}<\text{datatype}^{*} \text{pSrc}, \text{int srcStep}, \text{IppiSize roiSize}, \text{Ipp64f} \text{ value}[3]);

Supported values for \text{mod}:

8u\text{C3R} \quad 16u\text{C3R} \quad 16s\text{C3R}

\text{IppStatus ippiNorm_L2_\text{<mod>}(\text{const Ipp}<\text{datatype}^{*} \text{pSrc}, \text{int srcStep}, \text{IppiSize roiSize}, \text{Ipp64f} \text{ value}[4]);}

Supported values for \text{mod}:

8u\text{C4R} \quad 16u\text{C4R} \quad 16s\text{C4R}

Case 5: Operation on multi-channel floating-point data

\text{IppStatus ippiNorm_L2_32f\text{C3R}(const Ipp32f}^{*} \text{pSrc}, \text{int srcStep}, \text{IppiSize roiSize}, \text{Ipp64f} \text{ value}[3], \text{IppHintAlgorithm hint});

\text{IppStatus ippiNorm_L2_32f\text{C4R}(const Ipp32f}^{*} \text{pSrc}, \text{int srcStep}, \text{IppiSize roiSize}, \text{Ipp64f} \text{ value}[4], \text{IppHintAlgorithm hint});

Case 6: Masked operation on multi-channel data

IppStatus ippiNorm_L2_\text{<mod>}(\text{const Ipp}<\text{datatype}^{*} \text{pSrc}, \text{int srcStep}, \text{const Ipp8u}^{*} \text{pMask}, \text{int maskStep}, \text{IppiSize roiSize}, \text{int coi}, \text{Ipp64f}^{*} \text{pNorm});

Supported values for \text{mod}:

8u\text{C3CMR} \quad 16u\text{C3CMR} \quad 32f\text{C3CMR}

Include Files

ippcv.h
ippi.h

Domain Dependencies

Flavors declared in ippcv.h:

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Flavors declared in ippi.h:

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

\( pSrc \)  
Pointer to the source image ROI.

\( srcStep \)  
Distance in bytes between starts of consecutive lines in the source image.

\( pMask \)  
Pointer to the mask image.

\( maskStep \)  
Distance in bytes between starts of consecutive lines in the mask image.

\( roiSize \)  
Size of the source ROI in pixels.

\( coi \)  
Channel of interest (for color images only); can be 1, 2, or 3.

\( pValue \)  
Pointer to the computed L2-norm of pixel values.

\( value \)  
An array containing the computed L2-norms of channel values in case of multi-channel data.

\( pNorm \)  
Pointer to the computed norm value in the mask mode.

\( hint \)  
Option to select the algorithmic implementation of the function.

Description

The flavors of the function \texttt{ippiNorm\_L2} that perform masked operation are declared in the \texttt{ippcv.h} file. All other function flavors are declared in the \texttt{ippi.h} file. The function operates with ROI (see Regions of Interest in Intel IPP). It computes the L2-norm \( pValue \) (\( pNorm \) in mask mode) for the source image \( pSrc \). This norm is defined as the square root of the sum of squared pixel values in an image. Computation algorithm is specified by the \( hint \) argument (see Table "Hint Arguments for Image Moment Functions"). In the mask mode, the computation is done over pixels selected by nonzero mask values.

For non-masked operations on a multi-channel image (Case 4, 5), the norm is computed separately for each channel and stored in the array \( value \).

In the mask multi-channel mode (Case 6), the norm is computed for a single channel of interest specified by \( coi \).

Return Values

\texttt{ippStsNoErr}  
Indicates no error. Any other value indicates an error or a warning.

\texttt{ippStsNullPtrErr}  
Indicates an error when any of the specified pointers is NULL.

\texttt{ippStsSizeErr}  
Indicates an error condition if \( roiSize \) has a field with zero or negative value.

\texttt{ippStsStepErr}  
Indicates an error condition in mask mode, if \( srcStep \) or \( maskStep \) is less than \( roiSize.width * \text{<pixelSize>} \).

\texttt{ippStsNotEvenStepErr}  
Indicates an error condition in mask mode if steps for floating-point images cannot be divided by 4.

\texttt{ippStsCOIErr}  
Indicates an error when \( coi \) is not 1, 2, or 3.

NormDiff_Inf

\textit{Computes the infinity norm of differences between pixel values of two images.}
Syntax

Case 1: Operation on one-channel data

IppStatus ippiNormDiff_Inf_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppSize roiSize, Ipp64f* pValue);

Supported values for mod:

8u_C1R 16u_C1R 16s_C1R 32f_C1R

Case 2: Masked operation on one-channel data

IppStatus ippiNormDiff_Inf_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, const Ipp8u* pMask, int maskStep, IppSize roiSize, Ipp64f* pNorm);

Supported values for mod:

8u_C1MR 16u_C1MR 32f_C1MR

Case 3: Operation on multi-channel data

IppStatus ippiNormDiff_Inf_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppSize roiSize, Ipp64f value[3]);

Supported values for mod:

8u_C3R 16u_C3R 16s_C3R 32f_C3R

IppStatus ippiNormDiff_Inf_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppSize roiSize, Ipp64f value[4]);

Supported values for mod:

8u_C4R 16u_C4R 16s_C4R 32f_C4R

Case 4: Masked operation on multi-channel data

IppStatus ippiNormDiff_Inf_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, const Ipp8u* pMask, int maskStep, IppSize roiSize, int coi, Ipp64f* pNorm);

Supported values for mod:

8u_C3CMR 16u_C3CMR 32f_C3CMR

Include Files

ippcv.h
ippi.h

Domain Dependencies

Flavors declared in ippcv.h:
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib
Flavors declared in ippi.h:
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc1, pSrc2**: Pointers to the source images ROI.
- **src1Step, src2Step**: Distance in bytes between starts of consecutive lines in the source images.
- **pMask**: Pointer to the mask image.
- **maskStep**: Distance in bytes between starts of consecutive lines in the mask image.
- **roiSize**: Size of the source ROI in pixels.
- **pValue**: Pointer to the computed infinity norm of difference between pixel values.
- **value**: An array containing the computed infinity norms of difference between corresponding channel values in case of multi-channel data.
- **coi**: Channel of interest (for color images only); can be 1, 2, or 3.
- **pNorm**: Pointer to the computed norm value in the mask mode.

Description

The flavors of the functionippiNormDiff_Inf that perform masked operation are declared in the ippcv.h file. All other function flavors are declared in the ippi.h file. The function operates with ROI (see Regions of Interest in Intel IPP). It computes the infinity norm $pValue$ ($pNorm$ in the mask mode) of differences between pixel values of the two source images $pSrc1$ and $pSrc2$. This norm is defined as the largest absolute value of differences:

$$\text{norm} = \max |pSrc1-pSrc2|$$

In the mask mode, the computation is done over pixels selected by nonzero mask values.

For non-masked operations on multi-channel images (Case 3), the norm is computed separately for each pair of corresponding channels and stored in the array *value*.

In the mask multi-channel mode (Case 4), the norm is computed for a single channel of interest specified by coi.

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when any of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if *roiSize* has a field with zero or negative value.
- **ippStsStepErr**: Indicates an error condition in mask mode, if *src1Step*, *src2Step*, or *maskStep* is less than *roiSize.width* $\times \langle\text{pixelSize}\rangle$.
- **ippStsNotEvenStepErr**: Indicates an error condition in mask mode if steps for floating-point images cannot be divided by 4.
ippStsCOIERR Indicates an error when coi is not 1, 2, or 3.

**NormDiff_L1**

*Computes the L1- norm of differences between pixel values of two images.*

**Syntax**

**Case 1: Operation on one-channel integer data**

IppStatus ippiNormDiff_L1_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f* pValue);

Supported values for `mod`:

- 8u_C1R
- 16u_C1R
- 16s_C1R

**Case 2: Operation on one-channel floating-point data**

IppStatus ippiNormDiff_L1_32f_C1R(const Ipp32f* pSrc1, int src1Step, const Ipp32f* pSrc2, int src2Step, IppiSize roiSize, Ipp64f* pValue, IppHintAlgorithm hint);

**Case 3: Masked operation on one-channel data**

IppStatus ippiNormDiff_L1_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, const Ipp8u* pMask, int maskStep, IppiSize roiSize, Ipp64f* pNorm);

Supported values for `mod`:

- 8u_C1MR
- 16u_C1MR
- 32f_C1MR

**Case 4: Operation on multi-channel integer data**

IppStatus ippiNormDiff_L1_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[3]);

Supported values for `mod`:

- 8u_C3R
- 16u_C3R
- 16s_C3R

IppStatus ippiNormDiff_L1_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[4]);

Supported values for `mod`:

- 8u_C4R
- 16u_C4R
- 16s_C4R

**Case 5: Operation on multi-channel floating-point data**

IppStatus ippiNormDiff_L1_32f_C3R(const Ipp32f* pSrc1, int src1Step, const Ipp32f* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[3], IppHintAlgorithm hint);

IppStatus ippiNormDiff_L1_32f_C4R(const Ipp32f* pSrc1, int src1Step, const Ipp32f* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[4], IppHintAlgorithm hint);
Case 6: Masked operation on multi-channel data

IppStatus ippiNormDiff_L1_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp32f* pSrc2, int src2Step, const Ipp8u* pMask, int maskStep, IppiSize roiSize, int coi, Ipp64f* pNorm);

Supported values for mod:

8u_C3CMR  16u_C3CMR  32f_C3CMR

Include Files
ippcv.h
ippi.h

Domain Dependencies
Flavors declared in ippcv.h:
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Flavors declared in ippi.h:
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc1, pSrc2
src1Step, src2Step
pMask
maskStep
roiSize
coi
pValue
value
pNorm
hint

Pointers to the source images ROI.
Distance in bytes between starts of consecutive lines in the source images.
Pointer to the mask image.
Distance in bytes between starts of consecutive lines in the mask image.
Size of the source ROI in pixels.
Channel of interest (for color images only); can be 1, 2, or 3.
Pointer to the computed L1- norm of difference between pixel values.
An array containing the computed L1- norms of difference between channel values in case of multi-channel data.
Pointer to the computed norm value in the mask mode.
Option to select the algorithmic implementation of the function.

Description
The flavors of the function ippiNormDiff_L1 that perform masked operation are declared in the ippcv.h file. All other function flavors are declared in the ippi.h file. The function operates with ROI (see Regions of Interest in Intel IPP). It computes the L1-norm pValue (pNorm in the mask mode) of differences between pixel values of the two source image buffers pSrc1 and pSrc2. This norm is defined as the sum of absolute values of differences:

\[ \text{norm} = \sum |pSrc1-pSrc2| \]
Computation algorithm is specified by the hint argument (see Table "Hint Arguments for Image Moment Functions"). In the mask mode, the computation is done over pixels selected by nonzero mask values.

For non-masked operations on multi-channel images (Case 4,5), the norm is computed separately for each pair of the corresponding channels and stored in the array value.

In the mask multi-channel mode (Case 6), the norm is computed for a single channel of interest specified by coi.

Return Values

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error or a warning.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error when any of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error condition if roiSize has a field with zero or negative value.</td>
</tr>
<tr>
<td>ippStsStepErr</td>
<td>Indicates an error condition in mask mode, if src1Step, src2Step, or maskStep is less than roiSize.width * pixelSize.</td>
</tr>
<tr>
<td>ippStsNotEvenStepErr</td>
<td>Indicates an error condition in mask mode if steps for floating-point images cannot be divided by 4.</td>
</tr>
<tr>
<td>ippStsCOIErr</td>
<td>Indicates an error when coi is not 1, 2, or 3.</td>
</tr>
</tbody>
</table>

Example

The code example below shows how to use the function ippiNormDiff_L1_8u_C1R.

```c
void func_normdiff_l1()
{
    Ipp8u pSrc1[8*4];
    Ipp8u pSrc2[8*4];
    Ipp64f Value;
    int src1Step = 8;
    int src2Step = 8;
    IppiSize roi = (8,4);
    IppiSize roiSize = (5,4);

    ippiSet_8u_C1R(1, pSrc1, src1Step, roi);
    ippiSet_8u_C1R(2, pSrc2, src2Step, roi);

    ippiNormDiff_L1_8u_C1R( pSrc1, src1Step, pSrc2, src2Step, roiSize, &Value);
}
```

Result -> 20.0
NormDiff_L2
Computes the L2-norm of differences between pixel values of two images.

Syntax
Case 1: Operation on one-channel integer data
IppStatus ippiNormDiff_L2_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f* pValue);

Supported values for mod:

| 8u_C1R | 16u_C1R | 16s_C1R |

Case 2: Operation on one-channel floating-point data
IppStatus ippiNormDiff_L2_32f_C1R(const Ipp32f* pSrc1, int src1Step, const Ipp32f* pSrc2, int src2Step, IppiSize roiSize, Ipp64f* pValue, IppHintAlgorithm hint);

Case 3: Masked operation on one-channel data
IppStatus ippiNormDiff_L2_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, const Ipp8u* pMask, int maskStep, IppiSize roiSize, Ipp64f* pNorm);

Supported values for mod:

| 8u_C1MR | 16u_C1MR | 32f_C1MR |

Case 4: Operation on multi-channel integer data
IppStatus ippiNormDiff_L2_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[3]);

Supported values for mod:

| 8u_C3R | 16u_C3R | 16s_C3R |

IppStatus ippiNormDiff_L2_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[4]);

Supported values for mod:

| 8u_C4R | 16u_C4R | 16s_C4R |

Case 5: Operation on multi-channel floating-point data
IppStatus ippiNormDiff_L2_32f_C3R(const Ipp32f* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[3], IppHintAlgorithm hint);

IppStatus ippiNormDiff_L2_32f_C4R(const Ipp32f* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[4], IppHintAlgorithm hint);
Case 6: Masked operation on multi-channel data

```c
IppStatus ippiNormDiff_L2_Lmod(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, const Ipp8u* pMask, int maskStep, IppSize roiSize, int coi, Ipp64f* pNorm);
```

Supported values for `mod`:

- 8u_C3CMR
- 16u_C3CMR
- 32f_C3CMR

Include Files

- ippcv.h
- ippi.h

Domain Dependencies

Flavors declared in `ippcv.h`:

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Flavors declared in `ippi.h`:

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- `pSrc1`, `pSrc2`: Pointers to the source images ROI.
- `src1Step`, `src2Step`: Distance in bytes between starts of consecutive lines in the source images.
- `pMask`: Pointer to the mask image.
- `maskStep`: Distance in bytes between starts of consecutive lines in the mask image.
- `roiSize`: Size of the source ROI in pixels.
- `coi`: Channel of interest (for color images only); can be 1, 2, or 3.
- `pValue`: Pointer to the computed L2-norm of difference between pixel values.
- `value`: An array containing the computed L2-norms of difference between channel values in case of multi-channel data.
- `pNorm`: Pointer to the computed norm value in the mask mode.
- `hint`: Option to select the algorithmic implementation of the function.

Description

The flavors of the function `ippiNormDiff_L2` that perform masked operation are declared in the `ippcv.h` file. All other function flavors are declared in the `ippi.h` file. The function operates with ROI (see Regions of Interest in Intel IPP). It computes the L2-norm `pValue` (`pNorm` in the mask mode) of differences between pixel values of the two source image buffers `pSrc1` and `pSrc2`. This norm is defined as the square root of the sum of squared differences:

\[
\text{norm} = \sqrt{\sum_{i} (p_{\text{Src}1} - p_{\text{Src}2})^2}.
\]
Computation algorithm is specified by the hint argument (see Table "Hint Arguments for Image Moment Functions"). In the mask mode, the computation is done over pixels selected by nonzero mask values.

For non-masked operations on multi-channel images (Case 4,5), the norm is computed separately for each pair of the corresponding channels and stored in the array value.

In the mask multi-channel mode (Case 6), the norm is computed for a single channel of interest specified by coi.

**Return Values**

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error when any of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error condition if roiSize has a field with zero or negative value.
- ippStsStepErr: Indicates an error condition in mask mode, if src1Step, src2Step, or maskStep is less than roiSize.width * pixelSize.
- ippStsNotEvenStepErr: Indicates an error condition in mask mode if steps for floating-point images cannot be divided by 4.
- ippStsCOIErr: Indicates an error when coi is not 1, 2, or 3.

**NormRel_Inf**

*Computes the relative error for the infinity norm of differences between pixel values of two images.*

**Syntax**

**Case 1: Operation on one-channel data**

IppStatus ippiNormRel_Inf_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f* pValue);

Supported values for mod:

| 8u_C1R | 16u_C1R | 16s_C1R | 32f_C1R |

**Case 2: Masked operation on one-channel data**

IppStatus ippiNormRel_Inf_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, const Ipp8u* pMask, int maskStep, IppiSize roiSize, Ipp64f* pNorm);

Supported values for mod:

| 8u_C1MR | 16u_C1MR | 32f_C1MR |
Case 3: Operation on multi-channel data

IppStatus ippiNormRel_Inf_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[3]);

Supported values for mod:

8u_C3R  16u_C3R  16s_C3R  32f_C3R

IppStatus ippiNormRel_Inf_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[4]);

Supported values for mod:

8u_C4R  16u_C4R  16s_C4R  32f_C4R

Case 4: Masked operation on multi-channel data

IppStatus ippiNormRel_Inf_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, const Ipp8u* pMask, int maskStep, IppiSize roiSize, int coi, Ipp64f* pNorm);

Supported values for mod:

8u_C3CMR  16u_C3CMR  32f_C3CMR

Include Files

ippcv.h
ippi.h

Domain Dependencies

Flavors declared in ippcv.h:

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Flavors declared in ippi.h:

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc1, pSrc2  
Distance in bytes between starts of consecutive lines in the source images.

src1Step, src2Step  
Pointer to the source images ROI.

pMask  
Pointer to the mask image.

maskStep  
Distance in bytes between starts of consecutive lines in the mask image.

roiSize  
Size of the source ROI in pixels.

pValue  
Pointer to the computed relative error value.
An array containing the computed relative error values for separate channels in case of multi-channel data.

Channel of interest (for color images only); can be 1, 2, or 3.

Pointer to the computed relative norm value in the mask mode.

Description

The flavors of the function ippiNormRel_Inf that perform masked operation are declared in the ippcv.h file. All other function flavors are declared in theippi.h file. The function operates with ROI (see Regions of Interest in Intel IPP). It computes the infinity norm of differences between pixel values of two source buffers pSrc1 and pSrc2. This norm is defined as the largest absolute pixel value in an image. The output relative error pValue (pNorm in the mask mode) is then formed by dividing the computed norm of differences by the infinity norm of the second source image buffer pSrc2. In the mask mode, the computation is done over pixels selected by nonzero mask values.

For non-masked operations on multi-channel images (Case 3), the relative norm is computed separately for each pair of corresponding channels and stored in the array value.

In the mask multi-channel mode (Case 4), the relative norm is computed for a single channel of interest specified by coi.

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr

Indicates an error when any of the specified pointers is NULL.

ippStsSizeErr

Indicates an error condition if roiSize has a field with zero or negative value.

ippStsStepErr

Indicates an error condition in mask mode, if src1Step, src2Step, or maskStep is less than roiSize.width * <pixelSize>.

ippStsNotEvenStepErr

Indicates an error condition in mask mode if steps for floating-point images cannot be divided by 4.

ippStsCOIErr

Indicates an error when coi is not 1, 2, or 3.

ippStsDivByZero

Indicates a warning when the infinity norm of pSrc2 has a zero value.

NormRel_L1

Computes the relative error for the L1 norm of differences between pixel values of two images.

Syntax

Case 1: Operation on one-channel integer data

IppStatus ippiNormRel_L1_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppSize roiSize, Ipp64f* pValue);

Supported values for mod:

8u_C1R  16u_C1R  16s_C1R
Case 2: Operation on one-channel floating-point data

IppStatus ippiNormRel_L1_32f_C1R(const Ipp32f* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f* pValue, IppHintAlgorithm hint);

Case 3: Masked operation on one-channel data

IppStatus ippiNormRel_L1_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, const Ipp8u* pMask, int maskStep, IppiSize roiSize, Ipp64f* pNorm);

Supported values for mod:

8u_C1MR    16u_C1MR    32f_C1MR

Case 4: Operation on multi-channel integer data

IppStatus ippiNormRel_L1_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[3]);

Supported values for mod:

8u_C3R    16u_C3R    16s_C3R

IppStatus ippiNormRel_L1_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[4]);

Supported values for mod:

8u_C4R    16u_C4R    16s_C4R

Case 5: Operation on multi-channel floating-point data

IppStatus ippiNormRel_L1_32f_C3R(const Ipp32f* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[3], IppHintAlgorithm hint);

IppStatus ippiNormRel_L1_32f_C4R(const Ipp32f* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[4], IppHintAlgorithm hint);

Case 6: Masked operation on multi-channel data

IppStatus ippiNormRel_L1_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, const Ipp8u* pMask, int maskStep, IppiSize roiSize, int coi, Ipp64f* pNorm);

Supported values for mod:

8u_C3CMR    16u_C3CMR    32f_C3CMR

Include Files

ippcv.h
ippi.h

Domain Dependencies

Flavors declared in ippcv.h:
The flavors of the function `ippiNormRel_L1` that perform masked operation are declared in the `ippcv.h` file. All other function flavors are declared in the `ippi.h` file. The function operates with ROI (see Regions of Interest in Intel IPP). It computes the L1- norm of differences between pixel values of two source buffers `pSrc1` and `pSrc2`. This norm is defined as the sum of absolute pixel values in an image. The output relative error `pValue` (`pNorm` in the mask mode) is then formed by dividing the computed norm of differences by the L1- norm of the second source image buffer `pSrc2`. Computation algorithm is specified by the `hint` argument (see Table "Hint Arguments for Image Moment Functions"). In the mask mode, the computation is done over pixels selected by nonzero mask values.

For non-masked operations on multi-channel images (Cases 4, 5), the relative norm is computed separately for each pair of corresponding channels and stored in the array `value`.

In the mask multi-channel mode (Case 6), the relative norm is computed for a single channel of interest specified by `coi`.

**Return Values**

- `ippStsNoErr` Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr` Indicates an error when any of the specified pointers is `NULL`.
- `ippStsSizeErr` Indicates an error condition if `roiSize` has a field with zero or negative value.
- `ippStsStepErr` Indicates an error condition in mask mode, if `src1Step`, `src2Step`, or `maskStep` is less than `roiSize.width * <pixelSize>`.
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNotEvenStepErr</td>
<td>Indicates an error condition in mask mode if steps for floating-point images cannot be divided by 4.</td>
</tr>
<tr>
<td>ippStsCOIErr</td>
<td>Indicates an error when coi is not 1, 2, or 3.</td>
</tr>
<tr>
<td>ippStsDivByZero</td>
<td>Indicates a warning when the L1 norm of pSrc2 has a zero value.</td>
</tr>
</tbody>
</table>

**Example**

The code example below shows how to use the function ippiNormRel_L1_8u_C1R.

```c
void func_normrel_l1()
{
    Ipp8u pSrc1[8*4];
    Ipp8u pSrc2[8*4];
    Ipp64f Value;
    int src1Step = 8;
    int src2Step = 8;
    IppiSize roi = (8,4);
    IppiSize roiSize = (5,4);
    ippiSet_8u_C1R(1, pSrc1, src1Step, roi);
    ippiSet_8u_C1R(2, pSrc2, src2Step, roi);
    ippiNormRel_L1_8u_C1R( pSrc1, src1Step, pSrc2, src2Step, roiSize, &Value);
}
Result -> 0.5
```

**NormRel_L2**

*Computes the relative error for the L2 norm of differences between pixel values of two images.*

**Syntax**

**Case 1: Operation on one-channel integer data**

```c
IppStatus ippiNormRel_L2_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f* pValue);
```

Supported values for `mod`:

- 8u_C1R
- 16u_C1R
- 16s_C1R
Case 2: Operation on one-channel floating-point data

```c
IppStatus ippiNormRel_L2_32f_C1R(const Ipp32f* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f* pValue, IppHintAlgorithm hint);
```

Case 3: Masked operation on one-channel data

```c
IppStatus ippiNormRel_L2_<mod>(const Ipp<datatype>*>(pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, const Ipp8u* pMask, int maskStep, IppiSize roiSize, Ipp64f* pNorm);
```

Supported values for `mod`:

- 8u_C1MR
- 16u_C1MR
- 32f_C1MR

Case 4: Operation on multi-channel integer data

```c
IppStatus ippiNormRel_L2_<mod>(const Ipp<datatype>*(pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[3]);
```

Supported values for `mod`:

- 8u_C3R
- 16u_C3R
- 16s_C3R

```c
IppStatus ippiNormRel_L2_<mod>(const Ipp<datatype>*(pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[4]);
```

Supported values for `mod`:

- 8u_C4R
- 16u_C4R
- 16s_C4R

Case 5: Operation on multi-channel floating-point data

```c
IppStatus ippiNormRel_L2_32f_C3R(const Ipp32f* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[3], IppHintAlgorithm hint);
```

```c
IppStatus ippiNormRel_L2_32f_C4R(const Ipp32f* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp64f value[4], IppHintAlgorithm hint);
```

Case 6: Masked operation on multi-channel data

```c
IppStatus ippiNormRel_L2_<mod>(const Ipp<datatype>*(pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, const Ipp8u* pMask, int maskStep, IppiSize roiSize, int coi, Ipp64f* pNorm);
```

Supported values for `mod`:

- 8u_C3CMR
- 16u_C3CMR
- 32f_C3CMR

Include Files

- ippcv.h
- ippi.h

Domain Dependencies

Flavors declared in ippcv.h:
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Flavors declared in ippi.h:
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

\( pSrc1, pSrc2 \)
Pointers to the source images ROI.

\( src1Step, src2Step \)
Distance in bytes between starts of consecutive lines in the source images.

\( pMask \)
Pointer to the mask image.

\( maskStep \)
Distance in bytes between starts of consecutive lines in the mask image.

\( roiSize \)
Size of the source ROI in pixels.

\( coi \)
Channel of interest (for color images only); can be 1, 2, or 3.

\( pValue \)
Pointer to the computed relative error value.

\( value \)
An array containing the computed relative error values for separate channels in case of multi-channel data.

\( pNorm \)
Pointer to the computed relative norm value in the mask mode.

\( hint \)
Option to select the algorithmic implementation of the function.

Description

The flavors of the function ippiNormRel_L2 that perform masked operation are declared in the ippcv.h file. All other function flavors are declared in the ippi.h file. The function operates with ROI (see Regions of Interest in Intel IPP). It computes the L2- norm of differences between pixel values of two source buffers \( pSrc1 \) and \( pSrc2 \). This norm is defined as the square root of the sum of squared pixel values in an image. The output relative error \( pValue \) (\( pNorm \) in the mask mode) is then formed by dividing the computed norm of differences by the L2- norm of the second source image buffer \( pSrc2 \). Computation algorithm is specified by the \( hint \) argument (see Table "Hint Arguments for Image Moment Functions"). In the mask mode, the computation is done over pixels selected by nonzero mask values.

For non-masked operations on multi-channel images (Cases 4, 5), the relative norm is computed separately for each pair of corresponding channels and stored in the array \( value \).

In the mask multi-channel mode (Case 6), the relative norm is computed for a single channel of interest specified by \( coi \).

Return Values

\( ippStsNoErr \)
Indicates no error. Any other value indicates an error or a warning.

\( ippStsNullPtrErr \)
Indicates an error when any of the specified pointers is NULL.

\( ippStsSizeErr \)
Indicates an error condition if \( roiSize \) has a field with zero or negative value.

\( ippStsStepErr \)
Indicates an error condition in mask mode, if \( src1Step, src2Step, \) or \( maskStep \) is less than \( roiSize.width * <pixelSize> \).
ippStsNotEvenStepErr
Indicates an error condition in mask mode if steps for floating-point images cannot be divided by 4.

ippStsCOIErr
Indicates an error when coi is not 1, 2, or 3.

ippStsDivByZero
Indicates a warning when the L2 norm of pSrc2 has a zero value.

Example
The code example below shows how to use the function ippiNormRel_L2_8u_C1R.

```c
void func_normrel_l1()
{
    Ipp8u pSrc1[8*4];
    Ipp8u pSrc2[8*4];
    Ipp64f Value;
    int src1Step = 8;
    int src2Step = 8;
    IppiSize roi = (8,4);
    IppiSize roiSize = (5,4);

    ippiSet_8u_C1R(1, pSrc1, src1Step, roi);
    ippiSet_8u_C1R(10, pSrc2, src2Step, roi);
    ippiNormRel_L2_8u_C1R( pSrc1, src1Step, pSrc2, src2Step, roiSize, &Value);
}
Result -> 0.9
```

Image Quality Index
Intel IPP functions described in this section compute the universal image quality index [Wang02] that may be used as image and video quality distortion measure. It is mathematically defined by modeling the image distortion relative to the reference image as a combination of three factors: loss of correlation, luminance distortion, and contrast distortion.

If two images $f$ and $g$ are considered as a matrices with $M$ column and $N$ rows containing pixel values $f[i,j]$, $g[i,j]$, respectively ($0 \leq i < M$, $0 \leq j < N$), the universal image quality index $Q$ may be calculated as a product of three components:

$$Q = \frac{\sigma_f \sigma_g}{\sigma_f^2} \cdot \frac{2 \bar{f} \bar{g}}{(\bar{f}^2 + \bar{g}^2)^{3/2}} \cdot \frac{2 \sigma_f \sigma_g}{\sigma_f^2 + \sigma_g^2}$$

where
The first component is the correlation coefficient, which measures the degree of linear correlation between images $f$ and $g$. It varies in the range $[-1, 1]$. The best value 1 is obtained when $f$ and $g$ are linearly related, which means that $g[i,j] = af[i,j] + b$ for all possible values of $i$ and $j$. The second component, with a value range of $[0, 1]$, measures how close the mean luminance is between images. Since $\sigma_f$ and $\sigma_g$ can be considered as estimates of the contrast of $f$ and $g$, the third component measures how similar the contrasts of the images are. The value range for this component is also $[0, 1]$.

The range of values for the index $\varrho$ is $[-1, 1]$. The best value 1 is achieved if and only if the images are identical.

**QualityIndexGetBufferSize**

*Computes the size of the work buffer for the ippiQualityIndex function.*

**Syntax**

```c
IppStatus ippiQualityIndexGetBufferSize(IppDataType srcType, IppChannels ippChan, IppiSize roiSize, int* pBufferSize);
```

**Include Files**

`ippi.h`

**Domain Dependencies**

*Headers:* `ippcore.h`, `ippvm.h`, `ipps.h`

*Libraries:* `ippcore.lib`, `ippvm.lib`, `ipps.lib`

**Parameters**

- **srcType**
  - Data type of the source images. Possible values: `ipp8u`, `ipp16u`, or `ipp32f`.

- **ippChan**
  - Number of channels in the source images. Possible values: `ippC1`, `ippC3`, or `ippAC4`.

- **roiSize**
  - Size, in pixels, of the source images.

- **pBufferSize**
  - Pointer to the computed value of the buffer size, in bytes.

**Description**

The function computes the size of the work buffer, in bytes, for the `ippiQualityIndex` function and stores the result in the `pBufferSize` parameter.
Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr
Indicates an error when any of the specified pointers is NULL.

ippStsSizeErr
Indicates an error when roiSize is less than, or equal to zero.

ippStsDataTypeErr
Indicates an error when srcType has an illegal value.

ippStsChannelErr
Indicates an error when ippChan has an illegal value.

See Also

QualityIndex  Computes the universal image quality index.

QualityIndex
Computes the universal image quality index.

Syntax

Case 1: Operation on one-channel data
IppStatus ippiQualityIndex_<mod>(const Ipp<srcDatatype>* pSrc1, int src1Step, const Ipp<srcDatatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp<dstDatatype> pQualityIndex[1], Ipp8u* pBuffer);

Supported values for mod:

8u32f_C1R  16u32f_C1R  32f_C1R

Case 2: Operation on multi-channel data
IppStatus ippiQualityIndex_<mod>(const Ipp<srcDatatype>* pSrc1, int src1Step, const Ipp<srcDatatype>* pSrc2, int src2Step, IppiSize roiSize, Ipp<dstDatatype> pQualityIndex[3], Ipp8u* pBuffer);

Supported values for mod:

8u32f_C3R  16u32f_C3R  32f_C3R
8u32f_AC4R  16u32f_AC4R  32f_AC4R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc1, pSrc2
Pointers to the source images ROI.

csrc1Step, src2Step
Distance in bytes between starts of consecutive lines in the source images.
roiSize

Size of the source ROI in pixels.

pQualityIndex

Pointer to the computed quality index value.

pBuffer

Pointer to the buffer for internal calculations. To compute the size of the buffer, use the QualityIndexGetBufferSize function.

Description

This function operates with ROI (see Regions of Interest in Intel IPP). This function computes the universal image quality index for two images pSrc1 and pSrc2 according to the formula in the introduction section above. The computed value of the index is stored in pQualityIndex.

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr

Indicates an error when any of the specified pointers is NULL.

ippStsSizeErr

Indicates an error condition if roiSize has a field with zero or negative value.

ippStsStepErr

Indicates an error condition if src1Step or src2Step has a zero or negative value.

ippStsQualityIndexErr

Indicates an error condition if pixel values of one of the images are constant.

ippStsMemAllocErr

Indicates an error condition if memory allocation fails.

Example

To better understand usage of this function, refer to the QualityIndex.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

Result:

```
image1 (reference)  image2
```

Universal image quality index of the distorted image2 -> pQIndex = 0.6
See Also
QualityIndexGetBufferSize Computes the size of the work buffer for the `ippiQualityIndex` function.

## Image Proximity Measures

The functions described in this section compute the proximity (similarity) measure between an image and a template (another image). These functions may be used as feature detection functions, as well as the components of more sophisticated techniques.

There are several ways to compute the measure of similarity between two images. One way is to compute the Euclidean distance, or sum of the squared distances (SSD), of an image and a template. The smaller is the value of SSD at a particular pixel, the more similarity exists between the template and the image in the neighborhood of that pixel.

The squared Euclidean distance $S_{tx}(r,c)$ between a template and an image for the pixel in row $r$ and column $c$ is given by the equation:

$$S_{tx}(r,c) = \sum_{j=0}^{tplRows-1} \sum_{i=0}^{tplCols-1} \left[ t(j,i) - x\left(\frac{r+j}{2}, \frac{c+i}{2}\right) \right]^2$$

where $x(r,c)$ is the image pixel value in row $r$ and column $c$, and $t(j,i)$ is the template pixel value in row $j$ and column $i$; template size is $tplCols$ by $tplRows$ and its center is positioned at $(r,c)$.

The other similarity measure is the cross-correlation function: the higher is the cross-correlation at a particular pixel, the more similarity exists between the template and the image in the neighborhood of that pixel.

The cross-correlation $R_{tx}(r,c)$ between a template and an image at the pixel in row $r$ and column $c$ is computed by the equation:

$$R_{tx}(r,c) = \sum_{j=0}^{tplRows-1} \sum_{i=0}^{tplCols-1} t(j,i) \cdot x\left(\frac{r+j}{2}, \frac{c+i}{2}\right)$$

The cross-correlation function is dependent on the brightness variation across the image. To avoid this dependence, the correlation coefficient function is used instead. It is defined as:

$$G_{tx}(r,c) = \sum_{j=0}^{tplRows-1} \sum_{i=0}^{tplCols-1} \left[ t(j,i) \cdot \overline{x} - x\left(\frac{r+j}{2}, \frac{c+i}{2}\right) \cdot \overline{x} \right]$$

where $\overline{t}$ with the overline is the mean of the template, and $\overline{x}$ with the overline is the mean of the image in the region just under the template.

All Intel IPP proximity functions compute normalized values of SSD, cross-correlation and correlation coefficient that are defined as follows:

normalized SSD: $\sigma_{tx}(r,c)$

$$\sigma_{tx}(r,c) = \frac{S_{tx}(r,c)}{R_{tx}(r,c) R_{xx}(\frac{tplRows}{2}, \frac{tplCols}{2})}$$

normalized cross-correlation $\rho_{tx}(r,c)$:

$$\rho_{tx}(r,c) = \frac{R_{tx}(r,c)}{R_{xx}(r,c) R_{tt}(\frac{tplRows}{2}, \frac{tplCols}{2})}$$
Here $R_{xx}$ and $R_{tt}$ denote the autocorrelation of the image and the template, respectively:

$$R_{xx}(r, c) = \sum_{j=r-\frac{tplRows-1}{2}}^{r+\frac{tplRows-1}{2}} \sum_{i=c-\frac{tplCols-1}{2}}^{c+\frac{tplCols-1}{2}} x_{j, i} x_{j, i}$$

$$R_{tt}(\frac{tplRows}{2}, \frac{tplCols}{2}) = \sum_{j=0}^{tplRows-1} \sum_{i=0}^{tplCols-1} t_{j, i} t_{j, i}$$

Normalized correlation coefficient $\gamma_{tx}(r, c)$:

$$\gamma_{tx}(r, c) = \frac{G_{xx}(r, c)}{\sqrt{G_{xx}(r, c) G_{tt}(\frac{tplRows}{2}, \frac{tplCols}{2})}}$$

Here $G_{xx}$ and $G_{tt}$ denote the autocorrelations of the image and the template without constant brightness component, respectively:

$$G_{xx}(r, c) = \sum_{j=r-\frac{tplRows-1}{2}}^{r+\frac{tplRows-1}{2}} \sum_{i=c-\frac{tplCols-1}{2}}^{c+\frac{tplCols-1}{2}} (x_{j, i} - \bar{x}(r, c))^2$$

$$G_{tt}(\frac{tplRows}{2}, \frac{tplCols}{2}) = \sum_{j=0}^{tplRows-1} \sum_{i=0}^{tplCols-1} (t_{j, i} - \bar{t})^2$$

**SqrDistanceNormGetBufferSize**

*Computes the size of the work buffer for the ippiSqrDistanceNorm function.*

**Syntax**

```c
IppStatus ippiSqrDistanceNormGetBufferSize (IppiSize srcRoiSize, IppiSize tplRoiSize, IppEnum algType, int* pBufferSize);
```

**Include Files**

ippi.h

**Parameters**

- *srcRoiSize, tplRoiSize*  
  Size of the source/template ROI in pixels.

- *algType*  
  Bit-field mask for the algorithm type definition. Possible values are the results of composition of the IppAlgType, IppROIShape, and IppiNormOp values.

- *pBufferSize*  
  Pointer to the size of the work buffer.
Description
The `ippiSqrDistanceNormGetBufferSize` function computes the size, in bytes, of the external work buffer needed for the function that computes the Euclidean distance between an image and a template. The result is stored in the `pBufferSize` parameter.

Return Values
- **ippStsNoErr**: Indicates no error.
- **ippStsSizeErr**: Indicates an error when:
  - `srcRoiSize` or `tplRoiSize` is negative, or equal to zero
  - the value of `srcRoiSize` is less than the corresponding value of `tplRoiSize`
- **ippStsAlgTypeErr**: Indicates an error when:
  - the result of the bitwise AND operation between the `algType` and `ippAlgMask` values differs from the `ippAlgAuto`, `ippAlgDirect`, or `ippAlgFFT` values.
  - the result of the bitwise AND operation between the `algType` and `ippiROIMask` values differs from the `ippiROIFull`, `ippiROISame`, or `ippiROIValid` values.
  - the result of the bitwise AND operation between the `algType` and `ippiNormMask` values differs from the `ippiNormNone` or `ippiNorm` values.
- **ippStsNullErr**: Indicates an error when the `pBufferSize` is NULL.

See Also
- **Structures and Enumerators**
- **SqrDistanceNorm** Computes Euclidean distance between an image and a template.

Syntax
**Case 1: Operating with integer output**
```c
IppStatus ippiSqrDistanceNorm_8u_C1RSfs(const Ipp8u* pSrc, int srcStep, IppiSize srcRoiSize, const Ipp8u* pTpl, int tplStep, IppiSize tplRoiSize, Ipp8u* pDst, int dstStep, int scaleFactor, IppEnum algType, Ipp8u* pBuffer);
```

**Case 2: Operating on data with floating-point output**
```c
IppStatus ippiSqrDistanceNorm_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, IppiSize srcRoiSize, const Ipp<srcDatatype>* pTpl, int tplStep, IppiSize tplRoiSize, Ipp32f* pDst, int dstStep, IppEnum algType, Ipp8u* pBuffer);
```

Supported values for `mod`:
- `32f_C1R`
- `8u32f_C1R`
- `16u32f_C1R`

Include Files
`ippi.h`
Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

\begin{itemize}
\item \texttt{pSrc}  
Pointer to the source image ROI.
\item \texttt{srcStep}  
Distance, in bytes, between the starting points of consecutive lines in the source image.
\item \texttt{srcRoiSize}  
Size of the source ROI in pixels.
\item \texttt{pTpl}  
Pointer to the template image.
\item \texttt{tplStep}  
Distance, in bytes, between the starting points of consecutive lines in the template image.
\item \texttt{tplRoiSize}  
Size of the template ROI in pixels.
\item \texttt{pDst}  
Pointer to the destination image ROI.
\item \texttt{dstStep}  
Distance, in bytes, between the starting points of consecutive lines in the destination image.
\item \texttt{scaleFactor}  
Scale factor.
\item \texttt{algType}  
Bit-field mask for the algorithm type definition. Possible values are the results of composition of the \texttt{IppAlgType}, \texttt{IppiROIShape}, and \texttt{IppiNormOp} values.
\item \texttt{pBuffer}  
Pointer to the work buffer.
\end{itemize}

Description
Before using this function, you need to compute the size of the work buffer using the \texttt{ippiSqrDistanceNormGetBufferSize} function.

This function operates with ROI.

Depending on the \texttt{IppiNormOp} value set to the \texttt{algType} parameter, the function calculates the following results:

\begin{itemize}
\item \texttt{IppiNormNone}  
Squared Euclidean distances \( S_{tx}(r,c) \)
\item \texttt{IppiNorm}  
Normalized squared Euclidean distances \( \sigma_{tx}(r,c) \)
\end{itemize}

For more information on how each value is calculated, see Image Proximity Measures.

The size of the resulting matrix depends on the \texttt{IppiROIShape} value:

\begin{itemize}
\item \texttt{IppiROIFull}  
\( (W_S + W_T - 1) \times (H_S + H_T - 1) \)
\item \texttt{IppiRoisame}  
\( W_S \times H_S \)
\item \texttt{IppiROIvalid}  
\( (W_S - W_T + 1) \times (H_S - H_T + 1) \)
\end{itemize}

where

- \( W_S \), \( H_S \) is the width and height of the source image.
• $W_t$, $H_t$ is the width and height of the template image

Return Values

ippStsNoErr Indicates no error.

ippStsNullPtrErr Indicates an error when any of the specified pointers is NULL.

ippStsStepErr Indicates an error when the value of $\text{srcStep}$, $\text{tplStep}$, or $\text{dstStep}$ is negative, or equal to zero.

ippStsSizeErr Indicates an error when:
- $\text{srcRoiSize}$ or $\text{tplRoiSize}$ is negative, or equal to zero
- the value of $\text{srcRoiSize}$ is less than the corresponding value of $\text{tplRoiSize}$

ippStsAlgTypeErr Indicates an error when:
- the result of the bitwise AND operation between the $\text{algType}$ and $\text{ippAlgMask}$ values differs from the $\text{ippAlgAuto}$, $\text{ippAlgDirect}$, or $\text{ippAlgFFT}$ values;
- the result of the bitwise AND operation between the $\text{algType}$ and $\text{ippiROIMask}$ values differs from the $\text{ippiROIFull}$, $\text{ippiROISame}$, or $\text{ippiROIValid}$ values;
- the result of the bitwise AND operation between the $\text{algType}$ and $\text{ippiNormMask}$ values differs from the $\text{ippiNormNone}$ or $\text{ippiNorm}$ values;

Example

The code example below demonstrates how to use the $\text{ippiSqrDistanceNormGetBufferSize}$ and $\text{ippiSqrDistanceNorm}$ functions.

```c
IppStatus SqrDistanceNormExample()
{
    IppStatus status;
    Ipp32f pSrc[5*4];
    Ipp32f pTpl[5*4];
    Ipp32f pDst[9*7];//(5+5-1) x (4+4-1)

    IppiSize srcRoiSize = {5,4};
    IppiSize tplRoiSize = {5,4};
    IppiSize dstRoiSize = {9,7};
    int srcStep = 5*sizeof(Ipp32f);
    int tplStep = 5*sizeof(Ipp32f);
    int dstStep = 9*sizeof(Ipp32f);
    IppEnum funCfg = (IppEnum)(ippAlgAuto | ippiNorm | ippiROIFull);
    Ipp8u *pBuffer;
    int bufSize=0;

    ippSet_32f_C1R(2.0, pSrc, srcStep, srcRoiSize);
    ippSet_32f_C1R(1.0, pTpl, tplStep, tplRoiSize);

    status = ippiSqrDistanceNormGetBufferSize(srcRoiSize, tplRoiSize, ipp32f, funCfg, &bufSize);
    if ( status != ippStsNoErr ) return status;

    pBuffer = ippsMalloc_8u( bufSize );
```
status = ippiSqrDistanceNorm_32f_C1R( pSrc, srcStep, srcRoiSize, pTpl, tplStep, tplRoiSize, pDst, dstStep, funcCfg, pBuffer);
printf_2D_32f("pDst", pDst, dstRoiSize);
ippsFree( pBuffer );
return status;
}
The result is as follows:

<table>
<thead>
<tr>
<th>pDst -&gt;</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.24</td>
<td>1.58</td>
<td>1.29</td>
<td>1.12</td>
<td>1.00</td>
<td>1.12</td>
<td>1.29</td>
<td>1.58</td>
<td>2.24</td>
</tr>
<tr>
<td></td>
<td>1.58</td>
<td>1.12</td>
<td>0.91</td>
<td>0.79</td>
<td>0.71</td>
<td>0.79</td>
<td>0.91</td>
<td>1.12</td>
<td>1.58</td>
</tr>
<tr>
<td></td>
<td>1.29</td>
<td>0.91</td>
<td>0.75</td>
<td>0.65</td>
<td>0.58</td>
<td>0.65</td>
<td>0.75</td>
<td>0.91</td>
<td>1.29</td>
</tr>
<tr>
<td></td>
<td>1.12</td>
<td>0.79</td>
<td>0.65</td>
<td>0.56</td>
<td>0.50</td>
<td>0.56</td>
<td>0.65</td>
<td>0.79</td>
<td>1.12</td>
</tr>
<tr>
<td></td>
<td>1.29</td>
<td>0.91</td>
<td>0.75</td>
<td>0.65</td>
<td>0.58</td>
<td>0.65</td>
<td>0.75</td>
<td>0.91</td>
<td>1.29</td>
</tr>
<tr>
<td></td>
<td>1.58</td>
<td>1.12</td>
<td>0.91</td>
<td>0.79</td>
<td>0.71</td>
<td>0.79</td>
<td>0.91</td>
<td>1.12</td>
<td>1.58</td>
</tr>
<tr>
<td></td>
<td>2.24</td>
<td>1.58</td>
<td>1.29</td>
<td>1.12</td>
<td>1.00</td>
<td>1.12</td>
<td>1.29</td>
<td>1.58</td>
<td>2.24</td>
</tr>
</tbody>
</table>

See Also
Integer Result Scaling
Image Proximity Measures
Regions of Interest in Intel IPP
Structures and Enumerators
SqrDistanceNormGetSizeGetBufferSize Computes the size of the work buffer for the ippiSqrDistanceNorm function.

CrossCorrNormGetSizeGetBufferSize Computes the size of the work buffer for the ippiCrossCorrNorm function.

Syntax
IppStatusippiCrossCorrNormGetSizeGetBufferSize (IppSize srcRoiSize, IppSize tplRoiSize, IppEnum algType, int* pBufferSize);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
srcRoiSize, tplRoiSize
algType
pBufferSize

Size of the source/template ROI in pixels.
Bit-field mask for the algorithm type definition. Possible values are the results of composition of the IppAlgType, IppROIShape, and IppNormOp values.
Pointer to the size of the work buffer.
**Description**

The `ippiCrossCorrNormGetSizeBuffer` function computes the size, in bytes, of the external work buffer needed for the function that performs two-dimensional cross-correlation. The result is stored in the `pBufferSize` parameter.

**Return Values**

- `ippStsNoErr` Indicates no error.
- `ippStsSizeErr` Indicates an error when:
  - `srcRoiSize` or `tplRoiSize` is negative, or equal to zero
  - the value of `srcRoiSize` is less than the corresponding value of `tplRoiSize`.
- `ippStsAlgTypeErr` Indicates an error when:
  - the result of the bitwise AND operation between the `algType` and `ippAlgMask` differs from the `ippAlgAuto`, `ippAlgDirect`, or `ippAlgFFT` values.
  - the result of the bitwise AND operation between the `algType` and `ippiROIMask` differs from the `ippiROIFull`, `ippiROISame`, or `ippiROIValid` values.
  - the result of the bitwise AND operation between the `algType` and `ippiNormMask` differs from the `ippiNormNone`, `ippiNorm`, or `ippiNormCoefficient` values.
- `ippStsNullPtrErr` Indicates an error when `pBufferSize` is NULL.

**See Also**

**Structures and Enumerators**

- `CrossCorrNorm` Computes a normalized cross-correlation between an image and a template.

**CrossCorrNorm**

*Computes a normalized cross-correlation between an image and a template.*

**Syntax**

**Case 1: Operating on data with integer output**

```c
IppStatus ippiCrossCorrNorm_8u_C1RSfs(const Ipp8u* pSrc, int srcStep, IppSize srcRoiSize, const Ipp8u* pTpl, int tplStep, IppSize tplRoiSize, Ipp8u* pDst, int dstStep, int scaleFactor, IppEnum algType, Ipp8u* pBuffer);
```

**Case 2: Operating on data with floating-point output**

```c
IppStatus ippiCrossCorrNorm_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, IppSize srcRoiSize, const Ipp<srcDatatype>* pTpl, int tplStep, IppSize tplRoiSize, Ipp32f* pDst, int dstStep, IppEnum algType, Ipp8u* pBuffer);
```

Supported values for `mod`:

- `32f_C1R`
- `8u32f_C1R`
- `16u32f_C1R`

**Include Files**

`ippi.h`
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc        Pointer to the source image ROI.
srcStep     Distance, in bytes, between the starting points of consecutive lines in the source image.
srcRoiSize  Size of the source ROI in pixels.
pTpl        Pointer to the template image.
tplStep     Distance, in bytes, between the starting points of consecutive lines in the template image.
tplRoiSize  Size of the template ROI in pixels.
pDst        Pointer to the destination image ROI.
dstStep     Distance, in bytes, between the starting points of consecutive lines in the destination image.
scaleFactor Scale factor.
algType     Bit-field mask for the algorithm type definition. Possible values are the results of composition of the IppAlgType, IppiROIShape, and IppiNormOp values.
pBuffer     Pointer to the work buffer.

Description

This function operates with ROI.

Depending on the IppiNormOp value set to the algType parameter, the function calculates the following results:

<table>
<thead>
<tr>
<th>IppiNormOp Value</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippiNormNone</td>
<td>Cross-correlation values $R_{tx}(r,c)$</td>
</tr>
<tr>
<td>ippiNorm</td>
<td>Normalized cross-correlation values $\rho_{tx}(r,c)$</td>
</tr>
<tr>
<td>ippiNormCoefficient</td>
<td>Normalized correlation coefficients $\gamma_{tx}(r,c)$</td>
</tr>
</tbody>
</table>

For more information about how each value is calculated, see Image Proximity Measures.

The size of the resulting matrix depends on the IppiROIShape value:

<table>
<thead>
<tr>
<th>IppiROIShape Value</th>
<th>Matrix Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippiROIFull</td>
<td>$(W_S + W_T - 1) \times (H_S + H_T - 1)$</td>
</tr>
<tr>
<td>ippiROISame</td>
<td>$W_S \times H_S$</td>
</tr>
<tr>
<td>ippiROIValid</td>
<td>$(W_S - W_T + 1) \times (H_S - H_T + 1)$</td>
</tr>
</tbody>
</table>

where

- $W_S, H_S$ is the width and height of the source image
• \( W_t, H_t \) is the width and height of the template image

Before using this function, you need to compute the size of the work buffer using the `ippiCrossCorrNormGetBufferSize` function.

**Return Values**

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error when any of the specified pointers is NULL.
- ippStsStepErr: Indicates an error when the value of `srcStep`, `tplStep`, or `dstStep` is negative, or equal to zero.
- ippStsSizeErr: Indicates an error when:
  - the `srcRoiSize` or `tplRoiSize` is negative, or equal to zero.
  - the value of `srcRoiSize` is less than the corresponding value of the `tplRoiSize`.
- ippStsAlgTypeErr: Indicates an error when:
  - the result of the bitwise AND operation between the `algType` and `ippAlgMask` differs from the `ippAlgAuto`, `ippAlgDirect`, or `ippAlgFFT` values.
  - the result of the bitwise AND operation between the `algType` and `ippiROIMask` differs from the `ippiROIFull`, `ippiROISame`, or `ippiROIValid` values.
  - the result of the bitwise AND operation between the `algType` and `ippiNormMask` differs from the `ippiNormNone`, `ippiNorm`, or `ippiNormCoefficient` values.

**Example**

The code example below demonstrates how to use the `ippiCrossCorrNormGetBufferSize` and `ippiCrossCorrNorm` functions.

```c
IppStatus CrossCorrNormExample()
{
  IppStatus status;
  IppSize srcRoiSize = {5,4};
  IppSize tplRoiSize = {3,3};
  IppSize dstRoiSize = {5,4}; // same as src
  Ipp32f pSrc[5*4] = { 1.0f, 2.0f, 1.5f, 4.1f,  3.6f,
                       0.2f, 3.2f, 2.5f, 1.5f, 10.0f,
                       5.0f, 6.8f, 0.5f, 4.1f,  1.1f,
                       7.1f, 4.2f, 2.2f, 8.7f, 10.0f};
  Ipp32f pTpl[3*3] = {2.1f, 3.5f, 7.7f,
                      0.4f, 2.3f, 5.5f,
                      1.4f, 2.8f, 3.1f};
  Ipp32f pDst[5*4];
  int srcStep = 5*sizeof(Ipp32f);
  int tplStep = 3*sizeof(Ipp32f);
  int dstStep = 5*sizeof(Ipp32f);
  IppEnum funCfg = (IppEnum)(ippAlgAuto|ippiROISame|ippiNorm);
  Ipp8u *pBuffer;
  int bufSize;
  status = ippiCrossCorrNormGetBufferSize(srcRoiSize, tplRoiSize, ipp32f, funCfg, &bufSize);
  ... // code to use ippiCrossCorrNorm function
}
```
if ( status != ippStsNoErr ) return status;

pBuffer = ippsMalloc_8u( bufSize );

status = ippiCrossCorrNorm_32f_C1R(pSrc, srcStep, srcRoiSize, pTpl, tplStep, tplRoiSize,
    pDst, dstStep, funCfg, pBuffer);
printf_2D_32f("pDst", pDst, dstRoiSize);

ippsFree( pBuffer );
return status;
}

The result is as follows:

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.53</td>
<td>0.54</td>
<td>0.58</td>
<td>0.50</td>
<td>0.30</td>
</tr>
<tr>
<td>0.68</td>
<td>0.62</td>
<td>0.68</td>
<td>0.83</td>
<td>0.38</td>
</tr>
<tr>
<td>0.77</td>
<td>0.55</td>
<td>0.60</td>
<td>0.81</td>
<td>0.42</td>
</tr>
<tr>
<td>0.81</td>
<td>0.46</td>
<td>0.70</td>
<td>0.62</td>
<td>0.24</td>
</tr>
</tbody>
</table>

See Also

Integer Result Scaling
Regions of Interest in Intel IPP
Structures and Enumerators
Image Proximity Measures

**SADGetBufferSize**

*Computes the size of the work buffer for the ippiSAD function.*

**Syntax**

IppStatus ippiSADGetBufferSize(IppiSize srcRoiSize, IppiSize tplRoiSize, IppDataType
dataType, int numChannels, IppiROIShape shape, int* pBufferSize);

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- srcRoiSize: Size of the source ROI in pixels.
- tplRoiSize: Size of the template ROI in pixels.
- shape: Enumeration that defines the shape of the result of the SAD operation (see Structures and Enumerators).
- dataType: Type of the input data.
- numChannels: Number of channels in the images.
- pBufferSize: Pointer to the computed value of the external buffer size.
Description

The ippiSADGetBufferSize function computes the size of the external work buffer (in bytes) needed for
the ippiSAD function and stores the result in the *pBufferSize parameter.

Return Values

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error or a warning.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error condition if the pBufferSize pointer is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error condition if srcRoiSize or tplRoiSize has a field with a zero or negative value.</td>
</tr>
<tr>
<td>ippStsNotSupportedModeErr</td>
<td>Indicates an error condition if either shape does not equal ippiROIValid or numChannels does not equal 1.</td>
</tr>
</tbody>
</table>

SAD

Computes sums of absolute differences (SAD) for a template image and different locations within a source image where the template image can fit.

Syntax

IppStatus ippiSAD_<mod>({const Ipp<srcDatatype>* pSrc, int srcStep, IppiSize srcRoiSize, const Ipp<srcDatatype>* pTpl, int tplStep, IppiSize tplRoiSize, Ipp<dstDatatype>* pDst, int dstStep, IppiROIShape shape, int scaleFactor, Ipp8u* pBuffer);  
IppStatus ippiSAD_32f_C1R(const Ipp<srcDatatype>* pSrc, int srcStep, IppiSize srcRoiSize, const Ipp<srcDatatype>* pTpl, int tplStep, IppiSize tplRoiSize, Ipp<dstDatatype>* pDst, int dstStep, IppiROIShape shape, Ipp8u* pBuffer);  

Supported values for mod:

8u32s_C1Rsf  16u32s_C1Rsf  16s32s_C1Rsf

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pSrc</td>
<td>Pointer to the source image ROI.</td>
</tr>
<tr>
<td>srcStep</td>
<td>Distance, in bytes, between the starts of consecutive lines in the source image.</td>
</tr>
<tr>
<td>srcRoiSize</td>
<td>Size of the source ROI in pixels.</td>
</tr>
<tr>
<td>pTpl</td>
<td>Pointer to the template image ROI.</td>
</tr>
<tr>
<td>tplStep</td>
<td>Distance, in bytes, between the starts of consecutive lines in the template image.</td>
</tr>
</tbody>
</table>
The **ippiSAD function** operates with ROI (see Regions of Interest in Intel IPP).

The function only supports the `ippiROIValid` value of `shape`, and so the sizes of the destination ROI are different from the sizes of both the source ROI and template ROI and depend on those sizes as follows:

\[
\begin{align*}
\text{dstRoiSize.width} &= W = \text{srcRoiSize.width} - \text{tplRoiSize.width} + 1 \\
\text{dstRoiSize.height} &= H = \text{srcRoiSize.height} - \text{tplRoiSize.height} + 1
\end{align*}
\]

So there are exactly \(W \times H\) unique locations within the source image where the template image can fit. The top-left pixel determines each of these locations. For each location, the function computes absolute differences between corresponding pixel values of the source and template images, sums these differences to make the SAD value of the top-left pixel, and assigns the SAD value to the appropriate pixel in the destination buffer.

For integer flavors, the resulting values are also scaled by `scaleFactor`.

### Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if the `pSrc`, `pTpl`, `pDst`, or `pBuffer` pointer is NULL.
- **ippStsSizeErr**: Indicates an error condition if `srcRoiSize` or `tplRoiSize` has a field with a zero or negative value or if `srcRoiSize` in any direction is less than `tplRoiSize`.
- **ippStsStepErr**: Indicates an error condition if `srcStep`, `tplStep`, or `dstStep` has a zero or negative value or is not a multiple of the image data size (4 for floating-point images or 2 for short-integer images)
- **ippStsBadArgErr**: Indicates an error condition if `scaleFactor` < 0.
- **ippStsNotSupportedModeErr**: Indicates an error condition if intersection of the source and destination ROI is detected or if `shape` differs from `ippiROIValid`.

### Example

The code example below shows how to use the `ippiSAD_8u32s_C1RSfs` function.

```c
Ipp8u src[8*8] = {1, 2, 3, 4, 8, 8, 8, 8,
  1, 2, 3, 4, 8, 8, 8, 8,
  1, 2, 3, 4, 8, 8, 8, 8,
  1, 2, 3, 4, 8, 8, 8, 8,
  1, 2, 3, 4, 8, 8, 8, 8,
  1, 2, 3, 4, 8, 8, 8, 8,
  1, 2, 3, 4, 8, 8, 8, 8,
  1, 2, 3, 4, 8, 8, 8, 8,
...}
```
IppSize srcRoi = { 7, 7 };  
Ipp8u template[3*3] = { 
10, 10, 10,  
10, 10, 10,  
10, 10, 10,};  
IppSize tplRoi = { 3, 3 };  
Ipp32s dst[8*8] = {0, 0, 0, 0, 0, 0, 0, 0,  
0, 0, 0, 0, 0, 0, 0, 0,  
0, 0, 0, 0, 0, 0, 0, 0,  
0, 0, 0, 0, 0, 0, 0, 0,  
0, 0, 0, 0, 0, 0, 0, 0,  
0, 0, 0, 0, 0, 0, 0, 0,  
0, 0, 0, 0, 0, 0, 0, 0,  
0, 0, 0, 0, 0, 0, 0, 0};  
IppSize srcRoi = { 3, 3 };  
ippiSADGetBufferSize( srcRoi,  tplRoi, ippiROIVaid , 1, &bufferSize);  
Ipp8u* pBuffer = new Ipp8u [bufferSize];  
ippiSAD_8u32s_C1RSfs(src, 8, srcRoi, template, 3, tplRoi, dst, 8, ippiROIVaid , 1, pBuffer);  
Result:  
1 2 3 4 8 8 8 8 10 10 10 36 32 22 15 9 0 0 0  
1 2 3 4 8 8 8 8 src 10 10 10 tpl 36 32 22 15 9 0 0 0 dst  
1 2 3 4 8 8 8 8 10 10 10 36 32 22 15 9 0 0 0  
1 2 3 4 8 8 8 8 36 32 22 15 9 0 0 0  
1 2 3 4 8 8 8 8 36 32 22 15 9 0 0 0  
1 2 3 4 8 8 8 8 0 0 0 0 0 0 0 0  
1 2 3 4 8 8 8 8 0 0 0 0 0 0 0 0  
1 2 3 4 8 8 8 8 0 0 0 0 0 0 0 0  
1 2 3 4 8 8 8 8 0 0 0 0 0 0 0 0
This chapter describes the Intel® IPP image processing functions that perform geometric operations of resizing, rotating, warping and remapping an image.

Most functions performing geometric transform of an image use an interpolation algorithm to resample the image. The type of interpolation method to be used is passed to the function in the `interpolation` parameter for rotate, warp, and remap. For resize transform, the interpolation type is part of the function name.

The following interpolation algorithms are used:
- nearest neighbor
- linear interpolation
- cubic convolution
- supersampling
- interpolation using Lanczos window function
- interpolation with two-parameter cubic filters
- optional edge smoothing of the destination image.

The nearest neighbor algorithm is the fastest, while other methods yield higher quality results, but are slower.

Use one of the following constant identifiers for the applicable interpolation methods:

- `IPPI_INTER_NN` / `ippNearest` Nearest neighbor interpolation.
- `IPPI_INTER_LINEAR` / `ippLinear` Linear interpolation.
- `IPPI_INTER_CUBIC` Cubic interpolation.
- `IPPI_INTER_LANCZOS` / `ippLanczos` Interpolation using 3-lobed Lanczos window function.
- `IPPI_INTER_CUBIC2P_BSPLINE` Interpolation using B-spline.
- `IPPI_INTER_CUBIC2P_CATMULLROM` Interpolation using Catmull-Rom spline.
- `IPPI_INTER_CUBIC2P_B05C03` Interpolation using special cubic filter.
- `ippSuper` Supersampling interpolation.
- `ippCubic` Interpolation with two-parameter cubic filters.

For certain functions, you can combine the above interpolation algorithms with additional smoothing (antialiasing) of edges to which the original image borders are transformed. To use this edge smoothing, set the parameter `interpolation` to the bitwise OR of `IPPI_SMOOTH_EDGE` or `IPPI_SUBPIXEL_EDGE` and the desired interpolation mode, or use the special function flags.

**Caution**
You can use interpolation with edge smoothing option only in those geometric transform functions where this option is explicitly listed in the parameters definition section.

See appendix B “Interpolation in Image Geometric Transform Functions” for more information on the interpolation algorithms that are used in the library.

Super Sampling mode of resize transform has several limitations. It can be used only:
• for reducing image size
• for full images resize, while other interpolation modes can be used for full and tiled images for better speed/memory performance.

ROI Processing in Geometric Transforms

All the transform functions described in this chapter operate in rectangular regions of interest (ROIs) that are defined in both the source and destination images. The procedures for handling ROIs in geometric transform functions differ from those used in other functions (see Regions of Interest in Intel IPP in chapter 2). The main difference is that operations take place in the intersection of the transformed source ROI and the destination ROI. More specifically, all geometric transform functions (except those which perform inverse warping operations) handle ROIs with the following sequence of operations (see figure below):

• transform the rectangular ROI of the source image to quadrangle in the destination image;
• find the intersection of this quadrangle and the rectangular ROI of the destination image;
• update the destination image in the intersection area.

The coordinates in the source and destination images must have the same origin.

When using functions with ROI, every scan line of a source image has a stride. It is padded with zeroes for alignment, so the actual size of a scan line in bytes is often greater than the image width. The size of each row of image data in bytes is determined by the value of srcStep parameter, which gives distance in bytes between the starts of consecutive lines of an image.

To fully describe a rectangular ROI, both its origin (coordinates of top left corner) and size must be referenced. For geometrical transform functions, the source image ROI is specified by srcRoi parameter of IppiRect type, meaning that all four values describing the rectangular ROI are given explicitly.

The destination image ROI for different functions can be specified either by dstRoi parameter of IppiRect type, or dstRoiSize parameter of IppiSize type. In the latter case, only the destination ROI size is passed, while its origin is referenced by pDst pointer.

The destination image origin ROI for different functions can be specified by dstOffset parameter of IppiPoint type and dstSize parameter of IppiSize type. In this case, the processed destination image corresponds to the processed ROI of the destination image origin.
Geometric Transform Functions

ResizeYCbCr422GetBufSize

Computes the size of the external buffer for the NV12 resize transform.

Syntax

IppStatus ippiResizeYCbCr422GetBufSize(IppiRect srcROI, IppiSize dstRoiSize, int interpolation, int* pSize);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

srcROI Region of interest of the source image.
dstRoiSize Region of interest of the destination image.
interpolation Type of interpolation to apply to the source image:

IPP_INTER_NN Nearest neighbor interpolation
IPP_INTER_LINEAR Linear interpolation
IPP_INTER_CUBIC Cubic interpolation
IPPI_INTER_CUBIC2P_CATMULLROM Catmull-Rom cubic filter
IPP_INTER_LANCZOS Lanczos filter with size 6x6

pSize Pointer to the size, in bytes, of the external buffer.

Description

This function computes the size of the external buffer for the YCbCr resize transform.

Return Values

ippStsNoErr Indicates no error.
ippStsNullPtrErr Indicates an error if pSize is NULL.
ippStsSizeErr Indicates an error in the following cases:

• width of either source or destination ROI is less than 2
• height of either source or destination ROI is less than 1

ippStsDoubleSize Indicates a warning if width of wither source or destination ROI is not a multiple of 2.
ippsStsInterpolationErr Indicates an error if interpolation has an illegal value.

**ResizeYCbCr422**  
*Performs resizing of a 4:2:2 two-channel image.*

**Syntax**

```c
IppStatus ippiResizeYCbCr422_8u_C2R(const Ipp8u* pSrc, IppiSize srcSize, int srcStep, IppiRect srcROI, Ipp8u* pDst, int dstStep, IppiSize dstRoiSize, int interpolation, Ipp8u* pBuffer);
```

**Include Files**

`ippi.h`

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h  
**Libraries:** ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **pSrc**  
  Pointer to the source image.

- **srcSize**  
  Size, in pixels, of the source image.

- **srcStep**  
  Distance, in bytes, between the starting points of consecutive lines in the source image buffer.

- **srcROI**  
  Region of interest in the source image.

- **pDst**  
  Pointer to the destination image ROI.

- **dstStep**  
  Distance, in bytes, between the starting points of consecutive lines in the destination image buffer.

- **dstRoiSize**  
  Size of the destination ROI in pixels.

- **interpolation**  
  Type of interpolation to apply to the source image:

  -IPP_INTER_NN  
    Nearest neighbor interpolation

  -IPP_INTER_LINEAR  
    Linear interpolation

  -IPP_INTER_CUBIC  
    Cubic interpolation

  -IPPI_INTER_CUBIC2P_CATMULLROM  
    Catmull-Rom cubic filter

  -IPP_INTER_LANCZOS  
    Lanczos filter with size 6x6

- **pBuffer**  
  Pointer to the external buffer.

**Description**

This function operates with ROI (see ROI Processing in Geometric Transforms).

This function resizes the source image ROI to the destination image ROI origin. The function performs resampling of the result using the interpolation mode specified by the `interpolation` parameter, and stores it in the destination image ROI.
The source image is a two-channel image in the 4:2:2 sampling format in color spaces with decoupled luminance and chrominance components, for example, YUV422 or YCrCb422.

**Return Values**

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error if `pSrc`, `pDst`, or `pBuffer` is NULL.
- **ippStsSizeErr**: Indicates an error in the following cases:
  - width of either source or destination ROI is less than 2
  - height of either source or destination ROI is less than 1
- **ippStsDoubleSize**: Indicates a warning if width of either source or destination ROI is not a multiple of 2.
- **ippStsInterpolationErr**: Indicates an error if `interpolation` has an illegal value.
- **ippStsWrongIntersectROI**: Indicates a warning if `srcROI` does not intersect with the source image; no operation is required.

**Resize Functions with Prior Initialization**

This section describes the Intel® IPP resize functions that use the specification structure in operation. Before using these functions, you need to initialize the structure.

**Using Intel® IPP Resize Functions with Prior Initialization**

You can use one of the following approaches to image resizing:

- Resizing the whole image
- Resizing a tiled image with one prior initialization
- Resizing a tiled image with prior initialization for each tile

Interpolation algorithms of the Lanczos, Linear, and Cubic types use edge pixels of the source image that are out of the image origin. When calling the `ippiResize<Filter>` function with one of these interpolation algorithms applied, you need to specify the appropriate border type. The following border types are supported:

- Replicated borders: border pixels are replicated from the source image boundary pixels;
- Borders in memory: the source image border pixels are obtained from the source image pixels in memory;
- Mixed borders: a combined approach is applied.

**NOTE**

If you want to resize an image with antialiasing, follow the same instructions as provided below, but use `ippiResizeAntialiasing<Filter>Init` instead of `ippiResize<Filter>Init` for initialization, and `ippiResizeAntialiasing<Filter>` instead of `ippiResize<Filter>`, as a processing function.

**Resizing the Whole Image**

You can apply the approach described below to resize when source and destination images are fully accessible in memory. However, this method only runs on a single thread.

To resize the whole image:

1. Call the `ippiResizeGetSize` function with the appropriate interpolation type. This function uses source and destination image sizes to calculate how much memory must be allocated for the `IppResizeSpec` structure and initialization work buffer.
2. Initialize the IppResizeSpec structure by calling theippiResize<Filter>Init, where <Filter> can take one of the following values: Nearest, Linear, Cubic, Lanczos, and Super. These prerequisite steps allow resize to be called multiple times without recalculations.

3. Call theippiResizeGetBufferSize function for the initialized IppResizeSpec structure. This function uses the destination image size to calculate how much memory must be allocated for the resize work buffer.

4. CallippiResize<Filter> with the appropriate image type.

5. If you call theippiResize<Filter> function with a ippBorderInMem border or any mixed border type, the applied interpolation algorithm uses weighted values from edge pixels of the source image when outside the image boundaries. To obtain the size of the border required for correct edge calculation, call theippiResizeGetBorderSize function for the appropriate flavor. In case of mixed border type, out of image pixels are used only behind the non-replicated edge.

6. You can use mixed borders by using the bitwise OR operation between theippBorderRepl type and the following border types: ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight.

Figure Simple Image Resize shows a simple image resizing example, in which image resolution is increased by 1.5x.

Simple Image Resize
Example

The code example below demonstrates whole image resizing with the Lanczos interpolation method:

```c
IppStatus resizeExample_C3R(Ipp8u* pSrc, IppiSize srcSize, Ipp32s srcStep, Ipp8u* pDst, IppiSize dstSize, Ipp32s dstStep)
{
    IppiResizeSpec_32f* pSpec = 0;
    int specSize = 0, initSize = 0, bufSize = 0;
    Ipp8u* pBuffer = 0;
    Ipp8u* pInitBuf = 0;
    Ipp32u numChannels = 3;
    IppiPoint dstOffset = {0, 0};
    IppStatus status = ippStsNoErr;
    IppiBorderType border = ippBorderRepl;

    /* Spec and init buffer sizes */
    status =ippiResizeGetSize_8u(srcSize, dstSize, ippLanczos, 0, &specSize, &initSize);
    if (status != ippStsNoErr) return status;

    /* Memory allocation */
    pInitBuf = ippsMalloc_8u(initSize);
    pSpec      = (IppiResizeSpec_32f*)ippsMalloc_8u(specSize);
    if (pInitBuf == NULL || pSpec == NULL)
    {
        ippsFree(pInitBuf);
        ippsFree(pSpec);
        return ippStsNoMemErr;
    }

    /* Filter initialization */
    status =ippiResizeLanczosInit_8u(srcSize, dstSize, 3, pSpec, pInitBuf);
    if (status != ippStsNoErr)
    {
        ippsFree(pSpec);
        return status;
    }

    /* work buffer size */
    status =ippiResizeGetBufferSize_8u(pSpec, dstSize, numChannels, &bufSize);
    if (status != ippStsNoErr)
    {
        ippsFree(pSpec);
        return status;
    }

    pBuffer = ippsMalloc_8u(bufSize);
    if (pBuffer == NULL)
    {
        ippsFree(pSpec);
        return ippStsNoMemErr;
    }

    /* Resize processing */
    status =ippiResizeLanczos_Bu_C3R(pSrc, srcStep, pDst, dstStep, dstOffset, dstSize, border,
```
Resizing a Tiled Image with One Prior Initialization

You can apply the approach described below to resize when source and destination images are not fully accessible in memory, or to improve the performance of resizing by external threading.

The main difference between this approach and whole image resizing is that the processing is split into sections of the image called tiles. Each call of the Resize<Filter> function works with the destination image origin region of interest (ROI) that is defined by dstOffset and dstSize parameters. The destination and source ROI must be fully accessible in memory.

To resize an image with the tiled approach:

1. Call the ippiResizeGetSize function with the appropriate interpolation type. This function uses the source and destination image sizes to calculate how much memory must be allocated for the IppResizeSpec structure and initialization work buffer.
2. Initialize the IppResizeSpec structure by calling ippiResize<Filter>Init, where <Filter> can take one of the following values: Nearest, Cubic, Linear, and Lanczos.
3. Determine an appropriate partitioning scheme to divide the destination image into tiles. Tiles can be sets of rows or a regular grid of subimages. A simple vertical subdivision into sets of lines is often sufficient.
4. Obtain the source ROI for the defined destination tile by calling the ippiResizeGetSrcRoi function for the corresponding flavor. The algorithm uses edge pixels that are out of the source ROI to calculate edge pixels of the destination ROI. These out of the source ROI edge pixels must be accessible in memory.
5. If the source ROI is an interior field of the source image origin, obtain the border ROI size by calling the ippiResizeGetBorderSize function for the corresponding flavor.
6. If the source ROI is an edge tile, the algorithm can interpolate pixels beyond the image boundary as in the previous method.
7. If the source and destination images are fully accessible in memory, you can use the source ROI offset for the pSrc calculation. To obtain the offset, call the ippiResizeGetSrcOffset function for the corresponding flavor.
8. Call the ippiResizeGetBufferSize function to obtain the size of the resize work buffer required for each tile processing. The dstSize parameter must be equal to the tile size.
9. Call ippiResize<Filter> for each tile (ROI). The dstOffset parameter must specify the image ROI offset with respect to the destination image origin. The dstSize parameter must be equal to the ROI size. Parameters pSrc and pDst must point to the beginning of the source and destination ROI in memory respectively. The source and destination ROIs must be fully accessible in memory.

You can process tiles in any order. When using multiple threads you can process all tiles simultaneously.

**NOTE**
If you resize a tiled image with the Super Sampling algorithm, and the source image width to destination image width ratio is \( m/n \), you can reach better performance of resize operation if all destination tiles have width that is a multiple of \( n \).
Figure *Tiling Image Resize* shows the resize of the image divided into tiles.

**Tiling Image Resize**

---

**Example**

The code example below demonstrates a multithreading resize operation using OpenMP* with parallelization only in the y direction:

```c
#define MAX_NUM_THREADS 16

IppStatus tileResizeExample_C3R(Ipp8u* pSrc, IppiSize srcSize, Ipp32s srcStep, Ipp8u* pDst, IppiSize dstSize, Ipp32s dstStep)
{
    IppResizeSpec_32f* pSpec = 0;
    int specSize = 0, initSize = 0, bufSize = 0;
    Ipp8u* pBuffer = 0;
    Ipp8u* pInitBuf = 0;
    Ipp32u numChannels = 3;
    IppiPoint dstOffset = {0, 0};
    IppiPoint srcOffset = {0, 0};
    IppStatus status = ippStsNoErr;
    IppiBorderSize borderSize = {0, 0, 0, 0};
    IppiBorderType border = ippBorderRepl;
    int numThreads, slice, tail;
    int bufSize1, bufSize2;
    IppiSize dstTileSize, dstLastTileSize;
    IppStatus pStatus[MAX_NUM_THREADS];

    /* Spec and init buffer sizes */
    status =ippiResizeGetSize_8u(srcSize, dstSize, ippLinear, 0, &specSize, &initSize);
    if (status != ippStsNoErr) return status;
```

---

![Image](image.png)
/ * Memory allocation */
pInitBuf = ippsMalloc_8u(initSize);
pSpec  = (IppiResizeSpec_32f*)ippsMalloc_8u(specSize);

if (pInitBuf == NULL || pSpec == NULL)
{
    ippsFree(pInitBuf);
    ippsFree(pSpec);
    return ippStsNoMemErr;
}

/* Filter initialization */
status = ippiResizeLinearInit_8u(srcSize, dstSize, pSpec);
ippsFree(pInitBuf);

if (status != ippStsNoErr)
{
    ippsFree(pSpec);
    return status;
}

status = ippiResizeGetBorderSize_8u(pSpec, &borderSize);
if (status != ippStsNoErr)
{
    ippsFree(pSpec);
    return status;
}

/* General transform function */
/* Parallelized only by Y-direction here */
#ifpragma omp parallel num_threads(MAX_NUM_THREADS)
{
    #pragma omp master
    {
        numThreads = omp_get_num_threads();
        slice = dstSize.height / numThreads;
        tail  = dstSize.height % numThreads;

        dstTileSize.width = dstLastTileSize.width = dstSize.width;
        dstTileSize.height = slice;
        dstLastTileSize.height = slice + tail;

        ippiResizeGetBufferSize_8u(pSpec, dstTileSize, ippC3, &bufSize1);
        ippiResizeGetBufferSize_8u(pSpec, dstLastTileSize, ippC3, &bufSize2);

        pBuffer = ippsMalloc_8u(bufSize1 * (numThreads - 1) + bufSize2);
    }

    #pragma omp barrier
    {
        if (pBuffer)
        {
            Ipp32u  i;
            Ipp8u  *pSrcT, *pDstT;
            Ipp8u  *pOneBuf;
            IppiPoint srcOffset = {0, 0};
            IppiPoint dstOffset = {0, 0};
            IppiSize srcSizeT = srcSize;
...
Resizing a Tiled Image with Prior Initialization for Each Tile

You can apply this approach only in cases when the destination image can be divided into tiles so that each destination tile corresponds to a source image tile that starts with an integer pixel value origin. For example, if the ratio of the source and destination images sizes is 2/3, the destination image can be divided into 3x3 tiles, each of which corresponds to the source image tile 2x2.

This approach is useful if there are restrictions on memory size when processing an image, or if the image size is large and `ippiResizeGetBufferSize` function returns `ippStsSizeErr` error. The initialization data for a tile is less than the same data for the whole image.

Each tile of the source image can be considered as an independent image that can be resized. For interior tile processing, the border must be always of the `ippBorderInMem` type. If you need to replicate any borders of the source image origin, you should combine the border type of the outer tiles so that interior tiles edges have border in memory and external tile borders are of the specified border type. This approach enables the right linking order of tiles.
Resize of the Image Divided into Subimages shows the approach, when the source image is divided into several subimages that are resized independently.

**Resize of the Image Divided into Subimages**

![Figure: Resize of the Image Divided into Subimages](image)

- a) source image divided into subimages
- b) source image after resize transform

**Example**

The code example below divides the source image into tiles and resizes each image independently:

```c
IppStatus separateTileResizeExample_C3R(Ipp8u* pSrc, IppiSize srcTileSize, Ipp32s srcStep,
Ipp8u* pDst, IppiSize dstTileSize, Ipp32s dstStep, Ipp32s xNumTiles, Ipp32s yNumTiles)
{
    IppiResizeSpec_32f* pSpec = 0;
    int specSize = 0, initSize = 0, bufSize = 0;
    Ipp8u* pBuffer = 0;
    Ipp8u* pInitBuf = 0;
    Ipp32u numChannels = 3;
    IppStatus status = ippStsNoErr;

    /* tiles cycle */
    for (Ipp32s j = 0; j < xNumTiles; j++)
    {
        for (Ipp32s i = 0; i < yNumTiles; i++)
        {
            /* calculation of the destination image ROI offset */
            IppiPoint dstOffset = {j * dstTileSize.width, i * dstTileSize.height};
            Ipp8u* pDstT = pDst + dstStep * dstOffset.y + dstOffset.x * numChannels *
            sizeof(Ipp8u);

            /* calculation of the source image ROI offset */
            IppiPoint srcOffset = {j * srcTileSize.width, i * srcTileSize.height};
            Ipp8u* pSrcT = pSrc + srcStep * srcOffset.y + srcOffset.x * numChannels *
            sizeof(Ipp8u);
        }
    }
}
```
IppiBorderType borderT = ippBorderRep;
IppiPoint dstOffsetZero = {0, 0};

/* correction of the border type for the tile processing */
if (j > 0) /* the processed tile is not on the left image origin edge*/
{
    borderT = (IppiBorderType)((int)borderT | (int)ippBorderInMemLeft);
}
if (j < xNumTiles - 1) /* the processed tile is not on the right image origin edge*/
{
    borderT = (IppiBorderType)((int)borderT | (int)ippBorderInMemRight);
}
if (i > 0) /* the processed tile is not on the top image origin edge*/
{
    borderT = (IppiBorderType)((int)borderT | (int)ippBorderInMemTop);
}
if (i < yNumTiles - 1) /* the processed tile is not on the bottom image origin edge*/
{
    borderT = (IppiBorderType)((int)borderT | (int)ippBorderInMemBottom);
}

/* Spec and init buffer sizes */
status =ippiResizeGetSize_8u(srcTileSize, dstTileSize, ippLanczos, 0, &specSize,
&initSize);

if (status != ippStsNoErr) return status;

/* Memory allocation */
pInitBuf = ippsMalloc_8u(initSize);
pSpec = (IppiResizeSpec_32f*)ippsMalloc_8u(specSize);

if (pInitBuf == NULL || pSpec == NULL)
{
    ippsFree(pInitBuf);
    ippsFree(pSpec);
    return ippStsNoMemErr;
}

/* Filter initialization */
status =ippiResizeLanczosInit_8u(srcTileSize, dstTileSize, 3, pSpec, pInitBuf);
ippsFree(pInitBuf);

if (status != ippStsNoErr)
{
    ippsFree(pSpec);
    return status;
}

/* work buffer size */
status =ippiResizeGetBufferSize_8u(pSpec, dstTileSize, numChannels, &bufSize);
if (status != ippStsNoErr)
{
    ippsFree(pSpec);
    return status;
}
pBuffer = ippsMalloc_8u(bufSize);
if (pBuffer == NULL)
{
    ippsFree(pSpec);
    return ippStsNoMemErr;
}

/* Resize processing */
status = ippiResizeLanczos_8u_C3R(pSrcT, srcStep, pDstT, dstStep, dstOffsetZero,
dstTileSize, borderT, 0, pSpec, pBuffer);

ippsFree(pSpec);
ippsFree(pBuffer);
if (status != ippStsNoErr) return status;
}
return ippStsNoErr;

See Also
User-defined Border Types

ResizeGetSize

Computes the size of the specification structure and the size of the external temporary buffer for the resize transform initialization.

Syntax

Case 1: Processing images of 32-bit sizes

IppStatus ippiResizeGetSize_<mod>(IppiSize srcSize, IppiSize dstSize,
IppiInterpolationType interpolation, Ipp32u antialiasing, int* pSpecSize, int* pInitBufSize);

Supported values for mod:

8u 16u 32f 64f

IppStatus ippiResizeGetSize_16s(IppiSize srcSize, IppiSize dstSize,
IppiInterpolationType interpolation, Ipp32u antialiasing, int* pSpecSize, Ipp32s* pInitBufSize);

Case 2: Processing images with platform-aware functions

IppStatus ippiResizeGetSize_L(IppiSizeL srcSize, IppiSizeL dstSize, IppDataType
dataType, IppiInterpolationType interpolation, Ipp32u antialiasing, IppSizeL*
pSpecSize, IppSizeL* pInitBufSize);

Case 3: Processing images with threading layer (TL) functions

IppStatus ippiResizeGetSize_LT(IppiSizeL srcSize, IppiSizeL dstSize, IppDataType
dataType, IppiInterpolationType interpolation, Ipp32u antialiasing, IppSizeL*
pSpecSize, IppSizeL* pInitBufSize);

Include Files

ippi.h
Flavors with the _LT suffix:ippi_tl.h

Flavors with the _L suffix:ippi_l.h

**Domain Dependencies**

Flavors declared inippi.h:

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared inippi_tl.h:


**Parameters**

- srcSize
  
  Size, in pixels, of the source image.

- dstSize
  
  Size, in pixels, of the destination image.

- interpolation
  
  Interpolation method. Supported values: ippNearest, ippLinear, ippCubic, ippLanczos, and ippSuper.

- antialiasing
  
  Supported values: 1 - resizing with antialiasing, 0 - resizing without antialiasing.

- dataType
  
  Data type of the image. Supported values: ipp8u, ipp16u, ipp16s, ipp32f, ipp64f (only for linear interpolation).

- pSpecSize
  
  Pointer to the size, in bytes, of the specification structure.

- pInitBufSize
  
  Pointer to the size, in bytes, of the temporary buffer required for initialization of the specification structure.

**Description**

This function computes the size of the specification structure and the size of the external buffer for the following functions depending on the `interpolation` parameter value:

- ippiResizeAntialiasingCubicInit, ippiResizeAntialiasingLanczosInit, or ippiResizeAntialiasingLinearInit for resizing with antialiasing
- ippiResizeNearestInit, ippiResizeLinearInit, ippiResizeCubicInit, ippiResizeLanczosInit, or ippiResizeSuperInit for resizing without antialiasing

Interpolation algorithms have the following filter sizes:

<table>
<thead>
<tr>
<th>Nearest Neighbor</th>
<th>1x1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear</td>
<td>2x2</td>
</tr>
<tr>
<td>Cubic</td>
<td>4x4</td>
</tr>
<tr>
<td>2-lobed Lanczos</td>
<td>4x4</td>
</tr>
</tbody>
</table>

*NOTE* The ippiResizeGetSize function always returns non-zero value for the `pInitBufSize` parameter, even if the temporary buffer is not required for the specification structure initialization. The temporary buffer is only required when initializing the specification structure for the following functions: ippiResizeAntialiasingCubic, ippiResizeAntialiasingLanczos, ippiResizeAntialiasingLanczos, ippiResizeLanczos, and ippiResizeCubic.
Return Values

ippStsNoErr Indicates no error.

ippStsNullPtrErr Indicates an error if one of the specified pointers is NULL.

ippStsResizeNoOperation Indicates an error if width or height of the image is equal to zero.

ippStsSizeErr Indicates an error in the following cases:
- If the source image size is less than the filter size of the chosen interpolation method (except ippSuper).
- If one of the specified dimensions of the source image is less than the corresponding dimension of the destination image (for ippSuper method only).
- If the width or height of the source or destination image is negative.

ippStsExceededSizeErr Indicates an error in the following cases:
- If at least one of the computed values exceeds the maximum of the data type positive value pointed by pSpecSize or pInitBufSize correspondingly (the size of one of the processed images is too large).
- If width or height of the destination image or the source image exceeds 33554431 (0x1FFFFFF) (only for platform-aware and TL functions).

ippStsInterpolationErr Indicates an error if interpolation has an illegal value.

ippStsNoAntialiasing Indicates a warning if the specified interpolation method does not support antialiasing.

ippStsNotSupportedModeErr Indicates an error if the requested mode is not supported.

ippStsDataTypeErr Indicates an error if dataType has an illegal value.

ResizeGetBufferSize

Computes the size of the external buffer for image resizing.

Syntax

Case 1: Single precision

IppStatus ippiResizeGetBufferSize_<mod>(const IppiResizeSpec_32f* pSpec, IppiSize dstSize, Ipp32u numChannels, int* pBufSize);

Supported values for mod:
- 8u
- 16u
- 16s
- 32f

Case 2: Double precision

IppStatus ippiResizeGetBufferSize_64f(const IppiResizeSpec_64f* pSpec, IppiSize dstSize, Ipp32u numChannels, int* pBufSize);

Case 3: Processing images with platform-aware functions

IppStatus ippiResizeGetBufferSize_L(const IppiResizeSpec* pSpec, IppiSizeL dstSize, Ipp32u numChannels, IppiSizeL* pBufSize);
Case 4: Processing images with threading layer (TL) functions

IppStatus ippiResizeGetBufferSize_LT(const IppiResizeSpec_LT* pSpec, IppSizeL* pBufSize);

Include Files

ippi.h

Flavors with the _LT suffix: ippi_tl.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Flavors declared in ippi.h:
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:

Parameters

pSpec Pointer to the spec structure for the resize filter.
dstSize Size in pixels of the destination image.
numChannels Number of channels, possible values: 1, 3, or 4.
pBufSize Pointer to the size, in bytes, of the external buffer.

Description

This function computes the size of the external buffer for image resizing. The pSpec parameter defines the resize algorithm parameters. Prior to using the ippiResizeGetBufferSize function, you need to initialize the pSpec parameter by calling one of the following functions: ippiResizeNearestInit, ippiResizeLinearInit, ippiResizeCubicInit, ippiResizeLanczosInit, and ippiResizeSuperInit.

Return Values

IppStsNoErr Indicates no error.
IppStsNullPtrErr Indicates an error if pBufferSize pointer is NULL.
IppStsNoOperation Indicates a warning if width or height of the destination image is equal to zero.
IppStsContextMatchErr Indicates an error if pointer to the spec structure is invalid.
IppStsNumChannelErr Indicates an error if the value of numChannels is illegal.
IppStsSizeErr Indicates an error condition If width or height of the destination image is negative.
IppStsSizeWrn Indicates a warning if the destination image size is more than the destination image origin size.
IppStsExceededSizeErr Indicates an error if at least one of the computed values exceeds maximum of IppSizeL type positive value (the size of one of the processed images is too large).
ResizeGetBorderSize
*Computes the size of possible borders for the resize transform.*

**Syntax**

**Case 1: Interpolation with single precision**

```c
IppStatus ippiResizeGetBorderSize_<mod>(const IppiResizeSpec_32f* pSpec,
IppiBorderSize* borderSize);
```

**Case 2: Interpolation with double precision**

```c
IppStatus ippiResizeGetBorderSize_64f(const IppiResizeSpec_64f* pSpec,
IppiBorderSize* borderSize);
```

**Case 3: Processing images with platform-aware functions**

```c
IppStatus ippiResizeGetBorderSize_L(const IppiResizeSpec* pSpec,
IppiBorderSize* borderSize);
```

**Case 4: Processing images with threading layer (TL) functions**

```c
IppStatus ippiResizeGetBorderSize_LT(const IppiResizeSpec_LT* pSpec,
IppiBorderSize* borderSize);
```

**Include Files**

- ippi.h

  - Flavors with the `_LT` suffix: ippi_tl.h
  - Flavors with the `_L` suffix: ippi_l.h

**Domain Dependencies**

- Flavors declared in ippi.h:
  - Headers: ippcore.h, ippvm.h, ipps.h
  - Libraries: ippcore.lib, ippvm.lib, ipps.lib
- Flavors declared in ippi_tl.h:

**Parameters**

- `pSpec`  
  Pointer to the spec structure for the resize filter.

- `borderSize`  
  Size in pixels of necessary borders.

**Description**

This function computes the size of the source image ROI that is used by the corresponding resize transform and is out of the processing boundaries. The `pSpec` parameter defines the resize algorithm parameters. Prior to using the `ippiResizeGetBorderSize` function, you need to initialize the `pSpec` parameter by calling one of the following functions: `ippiResizeNearestInit`, `ippiResizeLinearInit`, `ippiResizeCubicInit`, `ippiResizeLanczosInit`, and `ippiResizeSuperInit`. 
Return Values

ippStsNoErr Indicates no error.
ippStsNullPtrErr Indicates an error if one of the specified pointers is NULL.
ippStsContextMatchErr Indicates an error if pointer to the spec structure is invalid.
ippStsBorderErr Indicates an error if border has an illegal value.

ResizeGetSrcOffset
Computes the offset of the source image for resizing by tile processing.

Syntax

Single precision
IppStatusippiResizeGetSrcOffset_<mod>(const IppiResizeSpec_32f* pSpec, IppiPoint dstOffset, IppiPoint* srcOffset);
Supported values for mod:
8u  16u  16s  32f

Double precision
IppStatusippiResizeGetSrcOffset_64f(const IppiResizeSpec_64f* pSpec, IppiPoint dstOffset, IppiPoint* srcOffset);

Processing images with platform-aware functions
IppStatusippiResizeGetSrcOffset_L(const IppiResizeSpec* pSpec, IppiPointL dstOffset, IppiPointL* srcOffset);

Include Files
ippi.h

Flavors with the _L suffix:ippi_l.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSpec Pointer to the spec structure for the resize filter.
dstOffset Offset of the tiled destination image with respect to the destination image origin.
srcOffset Offset of the source image.
This function computes the offset of the processed source image ROI using the offset of the processed destination image ROI for the corresponding resize transform by tile processing. The \texttt{pSpec} parameter defines the resize algorithm parameters. Prior to using the \texttt{ippiResizeGetSrcOffset} function, you need to initialize the \texttt{pSpec} parameter by calling one of the following functions: \texttt{ippiResizeNearestInit}, \texttt{ippiResizeLinearInit}, \texttt{ippiResizeCubicInit}, \texttt{ippiResizeLanczosInit}, or \texttt{ippiResizeSuperInit}.

### Return Values

- \texttt{ippStsNoErr} Indicates no error.
- \texttt{ippStsNullPtrErr} Indicates an error if one of the specified pointers is \texttt{NULL}.
- \texttt{ippStsContextMatchErr} Indicates an error if pointer to the spec structure is invalid.
- \texttt{ippStsOutOfRangeErr} Indicates an error if the destination image offset point is outside the destination image origin.

### \texttt{ippiResizeGetSrcRoi}

\textit{Computes the ROI of the source image for resizing by tile processing.}

### Syntax

**Single precision**

```c
IppStatus ippiResizeGetSrcRoi_<mod>(const IppiResizeSpec_32f* pSpec, IppiPoint dstRoiOffset, IppiSize dstRoiSize, IppiPoint* srcRoiOffset, IppiSize* srcRoiSize);
```

Supported values for \texttt{mod}:

- \texttt{8u}
- \texttt{16u}
- \texttt{16s}
- \texttt{32f}

**Double precision**

```c
IppStatus ippiResizeGetSrcRoi_64f(const IppiResizeSpec_64f* pSpec, IppiPoint dstRoiOffset, IppiSize dstRoiSize, IppiPoint* srcRoiOffset, IppiSize* srcRoiSize);
```

### Processing images with platform-aware functions

```c
IppStatus ippiResizeGetSrcRoi_L(const IppiResizeSpec* pSpec, IppiPointL dstRoiOffset, IppiSizeL dstRoiSize, IppiPointL* srcRoiOffset, IppiSizeL* srcRoiSize);
```

### Include Files

- \texttt{ippi.h}

Flavors with the \texttt{_L} suffix: \texttt{ippi_l.h}

### Domain Dependencies

#### Headers

- \texttt{ippcore.h, ippvm.h, ipps.h}

#### Libraries

- \texttt{ippcore.lib, ippvm.lib, ipps.lib}

### Parameters

- \texttt{pSpec} Pointer to the spec structure for the resize filter.
- \texttt{dstRoiOffset} Offset of the tiled destination image ROI.
dstRoiSize
Source image ROI size.

dstRoiOffset
Source image ROI offset.

dstRoiSize
Source image ROI size.

Description
This function computes the ROI of the processed source image using the processed ROI of the destination
image for the corresponding resize transform by tile processing. The pSpec parameter defines the resize
algorithm parameters. Prior to using theippiResizeGetSrcRoi function, you need to initialize the pSpec
parameter by calling one of the following functions: ippiResizeNearestInit, ippiResizeLinearInit,
ippiResizeCubicInit, ippiResizeLanczosInit, or ippiResizeSuperInit.

NOTE
If the destination ROI size exceeds the image origin, the source ROI will be obtained for an
intersection of the destination ROI and image origin.

Return Values
ippStsNoErr
Indicates no error.

ippStsNullPtrErr
Indicates an error if one of the specified pointers is NULL.

ippStsContextMatchErr
Indicates an error if pointer to the spec structure is invalid.

ippStsOutOfRangeErr
Indicates an error if the destination image offset point is outside the
destination image origin.

ippStsSizeWrn
Indicates a warning if the destination ROI exceeds the destination
image origin.

ResizeSetMode
Sets the rounding mode for resize functions

Syntax
IppStatus ippiResizeSetMode(IppHintAlgorithm hint, IppiResizeSpec* pSpec)

Include Files
ippi.h

Parameters
hint
Rounding mode for processing Ipp8u data. Possible values are:
ippAlgHintFast   Fast rounding mode (default).
ippAlgHintAccurate  Accurate rounding mode.

pSpec
Pointer to the specification structure for the resize filter.

Description
This function sets the roundMode for the resize algorithm.
If you provide the hint parameter with the ippAlgHintFast value, a faster but less accurate mode will be used. In this case, output pixel values can differ from the exact result by 1. If you choose ippAlgHintAccurate, a more accurate but slower mode will be used and all output pixel values will be exact.

Before using this function, initialize the specification structure using the initialization function for a required interpolation method.

**Return Values**

- `ippStsNoErr` Indicates no error.
- `ippStsNullPtrErr` Indicates an error when one of the specified pointers is NULL.
- `ippStsAccurateModeNotSupported` Indicates an error when the rounding mode is not supported for the selected data type. The rounding result can be inexact.

**ResizeNearestInit**

*Initializes the specification structure for image resizing with the nearest neighbor interpolation method.*

**Syntax**

IppStatus ippiResizeNearestInit_<mod>(IppiSize srcSize, IppiSize dstSize, IppiResizeSpec_32f* pSpec);

Supported values for `mod`:

- 8u, 16u, 16s, 32f

**Platform-aware function**

IppStatus ippiResizeNearestInit_L(IppiSizeL srcSize, IppiSizeL dstSize, IppDataType dataType, IppiResizeSpec* pSpec);

**Threading layer (TL) function**

IppStatus ippiResizeNearestInit_LT(IppiSizeL srcSize, IppiSizeL dstSize, IppDataType dataType, Ipp32u numChannels, IppiResizeSpec_LT* pSpec);

**Include Files**

ippi.h

Flavors with the _LT suffix: ippi_tl.h

Flavors with the _L suffix: ippi_l.h

**Domain Dependencies**

Flavors declared in ippi.h:

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:


**Parameters**

`srcSize` Size, in pixels, of the source image.
dstSize

Size, in pixels, of the destination image.

dataType

Data type of the image. Supported values: ipp8u, ipp16u, ipp16s, ipp32f, ipp64f.

pSpec

Pointer to the specification structure for the resize filter.

numChannels

Number of channels. Possible values are 1, 3, and 4.

Description

This function initializes the specification structure for the resize algorithm with the nearest neighbor interpolation method. To calculate the size of the specification structure object, call the ippiResizeGetSize function.

Return Values

ippStsNoErr
Indicates no error.

ippStsNullPtrErr
Indicates an error when one of the specified pointers is NULL.

ippStsNoOperation
Indicates a warning when width or height of the image is equal to zero.

ippStsSizeErr
Indicates an error when width or height of the source or destination image is negative.

ippStsDataTypeErr
Indicates an error if dataType has an illegal value.

ippStsExceededSizeErr
Indicates an error if width or height of the source or destination image exceeds 33554431 (0x1FFFFFF) (only for platform-aware and TL functions).

See Also

ResizeGetSize Computes the size of the specification structure and the size of the external temporary buffer for the resize transform initialization.

ResizeNearest Changes an image size using the nearest neighbor interpolation method.

Syntax

IppStatus ippiResizeNearest_<mod>(const Ipp<datatype>* pSrc, Ipp32s srcStep,
Ipp<datatype>* pDst, Ipp32s dstStep, IppPoint dstOffset, IppSize dstSize, const
IppiResizeSpec_32f* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C1R  16u_C1R  16s_C1R  32f_C1R
8u_C3R  16u_C3R  16s_C3R  32f_C3R
8u_C4R  16u_C4R  16s_C4R  32f_C4R
Platform-aware functions

IppStatus ippiResizeNearest_<mod>_L(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pDst, IppSizeL dstStep, IppiPointL dstOffset, IppSizeL dstSize, const IppiResizeSpec* pSpec, Ipp8u* pBuffer);

Supported values for \textit{mod}:

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R
- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 8u_C4R
- 16u_C4R
- 16s_C4R
- 32f_C4R

Threading layer (TL) functions

IppStatus ippiResizeNearest_<mod>_LT(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pDst, IppSizeL dstStep, const IppiResizeSpec_LT* pSpec, Ipp8u* pBuffer);

Supported values for \textit{mod}:

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R
- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 8u_C4R
- 16u_C4R
- 16s_C4R
- 32f_C4R

Include Files

ippi.h

Flavors with the \texttt{_LT} suffix: ippi_tl.h

Flavors with the \texttt{_L} suffix: ippi_l.h

Domain Dependencies

Flavors declared in ippi.h:

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:


Parameters

- \textit{pSrc} Pointer to the source image.
- \textit{srcStep} Distance, in bytes, between the starting points of consecutive lines in the source image buffer.
- \textit{pDst} Pointer to the destination image.
- \textit{dstStep} Distance, in bytes, between the starting points of consecutive lines in the destination image buffer.
- \textit{dstOffset} Offset of the tiled destination image with respect to the destination image origin.
- \textit{dstSize} Size of the destination image in pixels.
pSpec  
Pointer to the specification structure for the resize filter.

pBuffer  
Pointer to the work buffer.

**Description**

This function changes an image size using the nearest neighbor interpolation method. The image size can be either reduced or increased in each direction, depending on the destination image size.

This function operates with ROI. It resizes the source image ROI origin to the destination image ROI origin. You need to define the destination image ROI origin by the following parameters: the offset of the tiled destination image with respect to the destination image origin and the destination image size. The source image ROI origin is defined automatically. To obtain the source image ROI, use the `ippiResizeGetSrcRoi` function with the corresponding `mod` value. To obtain the source image ROI origin offset, call the `ippiResizeGetSrcOffset` function with the corresponding `mod` value. Parameters `pSrc` and `pDst` must point to the processed source and destination image ROI origins, respectively.

Function flavors operating on images of 64-bit sizes (with the `L` suffix) can process only whole images.

The interpolation algorithm applied uses only pixels of the source image origin that are inside of the image boundaries.

Before using the `ippiResizeNearest` function, you need to initialize the resize specification structure using the `ippiResizeNearestInit` function and compute the size of the external buffer `pBuffer` using the `ippiResizeGetBufferSize` function for the corresponding flavor.

**Return Values**

- `ippStsNoErr`  
  Indicates no error.

- `ippStsNullPtrErr`  
  Indicates an error when one of the specified pointers is `NULL`.

- `ippStsNoOperation`  
  Indicates a warning when width or height of the destination image is equal to zero.

- `ippStsContextMatchErr`  
  Indicates an error when pointer to the spec structure is invalid.

- `ippStsSizeErr`  
  Indicates an error when width or height of the source or destination image is negative.

- `ippStsStepErr`  
  Indicates an error when the step value is not data type multiple.

- `ippStsOutOfRangeErr`  
  Indicates an error when the destination image offset point is outside the destination image origin.

- `ippStsSizeWrn`  
  Indicates a warning when the destination image size is more than the destination image origin size.

**See Also**

ROI Processing in Geometric Transforms

- `ResizeGetSrcRoi`  
  Computes the ROI of the source image for resizing by tile processing.

- `ResizeGetSrcOffset`  
  Computes the offset of the source image for resizing by tile processing.

- `ResizeNearestInit`  
  Initializes the specification structure for image resizing with the nearest neighbor interpolation method.

- `ResizeGetBufferSize`  
  Computes the size of the external buffer for image resizing.

- `ResizeLinearInit`  
  *Initializes the specification structure for image resizing with the linear interpolation method.*
**Syntax**

IppStatus ippiResizeLinearInit_<mod>(IppiSize srcSize, IppiSize dstSize, IppiResizeSpec_32f* pSpec);

Supported values for mod:

| 8u | 16u | 16s | 32f |

IppStatus ippiResizeLinearInit_64f(IppiSize srcSize, IppiSize dstSize, IppiResizeSpec_64f* pSpec);

**Platform-aware function**

IppStatus ippiResizeLinearInit_L(IppiSize srcSize, IppiSize dstSize, IppiResizeSpec* pSpec);

IppStatus ippiResizeLinearInit_8u_L(IppiSizeL srcSize, IppiSizeL dstSize, IppHintAlgorithm hint, IppiResizeSpec* pSpec);

**Threading layer (TL) function**

IppStatus ippiResizeLinearInit_LT(IppiSizeL srcSize, IppiSizeL dstSize, IppDataType dataType, Ipp32u numChannels, IppiResizeSpec_LT* pSpec);

**Include Files**

ippi.h

Flavors with the _LT suffix: ippi_tl.h

Flavors with the _L suffix: ippi_l.h

**Domain Dependencies**

Flavors declared in ippi.h:

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:


**Parameters**

- **srcSize**
  - Size, in pixels, of the source image.

- **dstSize**
  - Size, in pixels, of the destination image.

- **dataType**
  - Data type of the image. Supported values: ipp8u, ipp16u, ipp16s, ipp32f, ipp64f.

- **hint**
  - Computation algorithm for processing Ipp8u data. Possible values are:
    - ippAlgHintNone: The hint is absent. Equivalent to ippAlgHintFast.
    - ippAlgHintFast: A faster but less accurate algorithm.
    - ippAlgHintAccurate: A slower but more accurate algorithm.

- **pSpec**
  - Pointer to the specification structure for the resize filter.
**numChannels**

Number of channels. Possible values are 1, 3, and 4.

**Description**

This function initializes the specification structure for the resize algorithm with the linear interpolation method. To calculate the size of the specification structure, call the `ippiResizeGetSize` function.

**NOTE**

The function with the parameter `hint` allows users to choose between a faster but less accurate algorithm and a slower but more accurate one. Without the parameter `hint` this function initializes the specification structure for the faster but less accurate algorithm for `Ipp8u` data type.

**Return Values**

- `ippStsNoErr` Indicates no error.
- `ippStsNullPtrErr` Indicates an error when one of the specified pointers is `NULL`.
- `ippStsNoOperation` Indicates a warning when width or height of the image is equal to zero.
- `ippStsSizeErr` Indicates an error if:
  - width or height of the source or destination image is negative
  - the source image size is less than the size of a 2x2 linear filter
- `ippStsDataTypeErr` Indicates an error if `dataType` has an illegal value.
- `ippStsExceededSizeErr` Indicates an error if width or height of the source or destination image exceeds 33554431 (0x1FFFFFF) (only for platform-aware or TL functions).
- `ippStsNumChannelErr` Indicates an error if `numChannel` has an illegal value.

**See Also**

- **ResizeGetSize** Computes the size of the specification structure and the size of the external temporary buffer for the resize transform initialization.

**ResizeLinear**

Changes an image size using the linear interpolation method.

**Syntax**

**Case 1: Single precision**

```c
IppStatus ippiResizeLinear_<mod>(const Ipp<datatype>* pSrc, Ipp32s srcStep, Ipp<datatype>* pDst, Ipp32s dstStep, IppiPoint dstOffset, IppiSize dstSize, IppiBorderType border, const Ipp<datatype>* pBorderValue, const IppiResizeSpec_32f* pSpec, Ipp8u* pBuffer);
```

**Supported values for mod:**

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R
- 8u_C3R
- 16u_C3R
- 16s_C3R
Case 2: Double precision

IppStatusippiResizeLinear_<mod>(const Ipp<datatype>* pSrc, Ipp32s srcStep, Ipp<datatype>* pDst, Ipp32s dstStep, IppiPoint dstOffset, IppiSize dstSize, IppiBorderType border, const Ipp<datatype>* pBorderValue, const IppiResizeSpec_<mod>* pSpec, Ipp8u* pBuffer);

Supported values for mod:

64f_C1R
64f_C3R
64f_C4R

Case 3: Platform-aware functions

IppStatusippiResizeLinear_<mod>_L(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pDst, IppSizeL dstStep, IppiPointL dstOffset, IppiSizeL dstSize, IppiBorderType border, const Ipp<datatype>* pBorderValue, const IppiResizeSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C1R 16u_C1R 16s_C1R 32f_C1R 64f_C1R
8u_C3R 16u_C3R 16s_C3R 32f_C3R 64f_C3R
8u_C4R 16u_C4R 16s_C4R 32f_C4R 64f_C4R

Case 3: Threading layer (TL) functions

IppStatusippiResizeLinear_<mod>_LT(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pDst, IppSizeL dstStep, IppiBorderType border, const Ipp8u* pBorderValue, const IppiResizeSpec_LT* pSpec, Ipp8u* pBuffer);

Supported values for mod:

8u_C1R 16u_C1R 16s_C1R 32f_C1R 64f_C1R
8u_C3R 16u_C3R 16s_C3R 32f_C3R 64f_C3R
8u_C4R 16u_C4R 16s_C4R 32f_C4R 64f_C4R

Include Files

ippi.h

Flavors with the _LT suffix: ippi_tl.h
Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Flavors declared in ippi.h:
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared inippi_tl.h:

Parameters

pSrc
Pointer to the source image.

srcStep
Distance, in bytes, between the starting points of consecutive lines in the source image buffer.

pDst
Pointer to the destination image.

dstStep
Distance, in bytes, between the starting points of consecutive lines in the destination image buffer.

dstOffset
Offset of the tiled destination image with respect to the destination image origin.

dstSize
Size of the destination image in pixels.

border
Type of border. Possible values are:

  ippBorderRepl  Border is replicated from the edge pixels.
  ippBorderInMem Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between the ippBorderRepl type and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight types.

pBorderValue
Pointer to the constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

pSpec
Pointer to the specification structure for the resize filter.

pBuffer
Pointer to the work buffer.

Description

This function changes the size of an image using the linear interpolation method. The image size can be either reduced or increased in each direction, depending on the destination image size.

This function operates with ROI. It resizes the source image ROI origin to the destination image ROI origin. You need to define the destination image ROI origin by the following parameters: the offset of the tiled destination image with respect to the destination image origin and the destination image size. The source image ROI origin is defined automatically. To obtain the source image ROI, use theippiResizeGetSrcRoi function with the corresponding mod value. To obtain the source image ROI origin offset, call theippiResizeGetSrcOffset function with the corresponding mod value. Parameters pSrc and pDst must point to the processed source and destination image ROI origins, respectively.

The interpolation algorithm applied uses edge pixels of the source image that are out of the image origin. The functionippiResizeLinear uses in calculation the weighted values of these outer pixels. To obtain the size of the out of the source image origin, call theippiResizeGetBorderSize function for the corresponding flavor.
If the border type is equal to ippBorderRepl, the source image edge pixels are replicated out of the image origin. If the border type is equal to ippBorderInMem, the outer pixels are obtained from the out of the source image origin space. For the mixed border types, the combined approach is applied.

Before using theippiResizeLinear function, you need to initialize the specification structure using theippiResizeLinearInit function and compute the size of the external buffer pBuffer using theippiResizeGetBufferSize function for the corresponding flavor.

**Return Values**

- **ippStsNoErr**
  - Indicates no error.
- **ippStsNullPtrErr**
  - Indicates an error when one of the specified pointers is NULL.
- **ippStsNoOperation**
  - Indicates a warning when width or height of the destination image is equal to zero.
- **ippStsBorderErr**
  - Indicates an error when the border value is illegal.
- **ippStsContextMatchErr**
  - Indicates an error when pointer to the specification structure is invalid.
- **ippStsNotSupportedModeErr**
  - Indicates an error when the requested mode is not supported.
- **ippStsSizeErr**
  - Indicates an error when width or height of the source or destination image is negative.
- **ippStsStepErr**
  - Indicates an error when the step value is not a multiple of data type.
- **ippStsOutOfRangeErr**
  - Indicates an error when the destination image offset point is outside the destination image origin.
- **ippStsSizeWrn**
  - Indicates a warning when the destination image size is more than the destination image origin size.

**See Also**

ROI Processing in Geometric Transforms

- **ResizeGetSrcRoi** Computes the ROI of the source image for resizing by tile processing.
- **ResizeGetSrcOffset** Computes the offset of the source image for resizing by tile processing.

User-defined Border Types

- **ResizeGetBorderSize** Computes the size of possible borders for the resize transform.
- **ResizeLinearInit** Initializes the specification structure for image resizing with the linear interpolation method.
- **ResizeGetBufferSize** Computes the size of the external buffer for image resizing.

**ResizeCubicInit**

*Initializes the specification structure for image resizing using interpolation with two-parameter cubic filters.*

**Syntax**

```c
IppStatus ippiResizeCubicInit_<mod>(IppiSize srcSize, IppiSize dstSize, Ipp32f valueB, Ipp32f valueC, IppResizeSpec_32f* pSpec, Ipp8u* pInitBuf);
```

Supported values for mod:

- 8u
- 16u
- 16s
- 32f
Platform-aware functions

IppStatus ippiResizeCubicInit_L(IppiSizeL srcSize, IppiSizeL dstSize, IppDataType dataType, Ipp32f valueB, Ipp32f valueC, IppiResizeSpec* pSpec, Ipp8u* pInitBuf);
IppStatus ippiResizeCubicInit_8u_L(IppiSizeL srcSize, IppiSizeL dstSize, Ipp32f valueB, Ipp32f valueC, IppHintAlgorithm hint, IppiResizeSpec* pSpec, Ipp8u* pInitBuf);

Threading layer (TL) functions

IppStatus ippiResizeCubicInit_LT(IppiSizeL srcSize, IppiSizeL dstSize, IppDataType dataType, Ipp32u numChannels, Ipp32f valueB, Ipp32f valueC, IppiResizeSpec_LT* pSpec, Ipp8u* pInitBuf);

Include Files

ippi.h

Flavors with the _LT suffix: ippi_tl.h
Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Flavors declared in ippi.h:
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:

Parameters

srcSize
Size, in pixels, of the source image.
dstSize
Size, in pixels, of the destination image.
dataType
Data type of the image. Supported values: ipp8u, ipp16u, ipp16s, ipp32f, ipp64f.

hint
Computation algorithm for processing Ipp8u data. Possible values are:
ippAlgHintNone The hint is absent. Equivalent to ippAlgHintFast.
ippAlgHintFast A faster but less accurate algorithm.
ippAlgHintAccurate A slower but more accurate algorithm.

numChannels
Number of channels, possible values: 1, 3, or 4.

valueB
The first parameter for cubic filters.

valueC
The second parameter for cubic filters.

pSpec
Pointer to the specification structure for the resize filter.

pInitBuf
Pointer to the temporary buffer for the cubic filter initialization.
**Description**

This function initializes the specification structure for the resize algorithm with interpolation with two-parameter cubic filters. To calculate the size of the specification structure, call the `ippiResizeGetSize` function.

Before using this function, you need to calculate the size of the specification structure and the external buffer `pInitBuf` using the `ippiResizeGetSize` function for the corresponding flavor.

**NOTE**

The function with the parameter `hint` allows users to choose between a faster but less accurate algorithm and a slower but more accurate one. Without the parameter `hint` this function initializes the specification structure for the faster but less accurate algorithm for `Ipp8u` data type.

**Return Values**

- `ippStsNoErr`: Indicates no error.
- `ippStsNullPtrErr`: Indicates an error when one of the specified pointers is `NULL`.
- `ippStsNoOperation`: Indicates a warning when width or height of the image is equal to zero.
- `ippStsSizeErr`: Indicates an error if:
  - width or height of the source or destination image is negative
  - the source image size is less than the size of a 2x2 linear filter
- `ippStsDataTypeErr`: Indicates an error if `dataType` has an illegal value.
- `ippStsExceededSizeErr`: Indicates an error if width or height of the source or destination image exceeds 33554431 (0x1FFFFFF) (only for platform-aware and TL functions).
- `ippStsNumChannelErr`: Indicates an error if `numChannel` has an illegal value.

**See Also**

- `ResizeGetSize` Computes the size of the specification structure and the size of the external temporary buffer for the resize transform initialization.

- `ResizeCubic` Changes an image size using interpolation with two-parameter cubic filters.

**Syntax**

```c
IppStatus ippiResizeCubic_<mod>(const Ipp<datatype>* pSrc, Ipp32s srcStep, Ipp<datatype>* pDst, Ipp32s dstStep, IppiPoint dstOffset, IppiSize dstSize, IppiBorderType border, const Ipp<datatype>* pBorderValue, const IppiResizeSpec_32f* pSpec, Ipp8u* pBuffer);
```

Supported values for `mod`:

- 8u_C1R
- 8u_C3R
- 16u_C1R
- 16u_C3R
- 16s_C1R
- 16s_C3R
- 32f_C1R
- 32f_C3R
Platform-aware functions

IppStatus ippiResizeCubic_<mod>_L(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pDst, IppSizeL dstStep, IppPointL dstOffset, IppSizeL dstSize, IppiBorderType border, const Ipp<datatype>* pBorderValue, const IppiResizeSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R
- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 8u_C4R
- 16u_C4R
- 16s_C4R
- 32f_C4R

Threading layer (TL) functions

IppStatus ippiResizeCubic_<mod>_LT(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pDst, IppSizeL dstStep, IppiBorderType border, const Ipp<datatype>* pBorderValue, const IppiResizeSpec_LT* pSpec, Ipp8u* pBuffer);

Supported values for mod:

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R
- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 8u_C4R
- 16u_C4R
- 16s_C4R
- 32f_C4R

Include Files

ippi.h

Flavors with the _LT suffix: ippi_tl.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Flavors declared in ippi.h:

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:


Parameters

- pSrc: Pointer to the source image.
- srcStep: Distance, in bytes, between the starting points of consecutive lines in the source image buffer.
- pDst: Pointer to the destination image.
- dstStep: Distance, in bytes, between the starting points of consecutive lines in the destination image buffer.
**dstOffset**
Offset of the tiled destination image with respect to the destination image origin.

**dstSize**
Size of the destination image in pixels.

**border**
Type of border. Possible values are:
- ippBorderRepl: Border is replicated from the edge pixels.
- ippBorderInMem: Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between the ippBorderRepl type and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight types.

**pBorderValue**
Pointer to the constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

**pSpec**
Pointer to the spec structure for the resize filter.

**pBuffer**
Pointer to the work buffer.

**Description**
This function changes an image size using interpolation with two-parameter cubic filters. The image size can be either reduced or increased in each direction, depending on the destination image size.

This function operates with ROI. It resizes the source image ROI origin to the destination image ROI origin. You need to define the destination image ROI origin by the following parameters: the offset of the tiled destination image with respect to the destination image origin and the destination image size. The source image ROI origin is defined automatically. To obtain the source image ROI, use theippiResizeGetSrcRoi function with the corresponding mod value. To obtain the source image ROI origin offset, call theippiResizeGetSrcOffset function with the corresponding mod value. Parameters pSrc and pDst must point to the processed source and destination image ROI origins, respectively.

The interpolation algorithm applied uses edge pixels of the source image that are out of the image origin. The functionippiResizeCubic uses in calculation the weighted values of these outer pixels. To obtain the size of the out of the source image origin, call theippiResizeGetBorderSize function for the corresponding flavor.

If the border type is equal to ippBorderRepl, the source image edge pixels are replicated out of the image origin. If the border type is equal to ippBorderInMem, the outer pixels are obtained from the out of the source image origin space. For the mixed border types, the combined approach is applied.

Before using theippiResizeLinear function, you need to initialize the specification structure using theippiResizeCubicInit function and compute the size of the external buffer pBuffer using theippiResizeGetBufferSize function for the corresponding flavor.

**Return Values**
- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error when one of the specified pointers is NULL.
- ippStsNoOperation: Indicates a warning when width or height of the destination image is equal to zero.
- ippStsBorderErr: Indicates an error when the border value is illegal.
ippStsContextMatchErr
Indicates an error when pointer to the spec structure is invalid.

ippStsNotSupportedModeErr
Indicates an error when the requested mode is not supported.

ippStsSizeErr
Indicates an error when width or height of the source or destination image is negative.

ippStsStepErr
Indicates an error when the step value is not data type multiple.

ippStsOutOfRangeErr
Indicates an error when the destination image offset point is outside the destination image origin.

ippStsSizeWrn
Indicates a warning when the destination image size is more than the destination image origin size.

See Also
ROI Processing in Geometric Transforms
ResizeGetSrcRoi Computes the ROI of the source image for resizing by tile processing.
ResizeGetSrcOffset Computes the offset of the source image for resizing by tile processing.
User-defined Border Types
ResizeGetBorderSize Computes the size of possible borders for the resize transform.
ResizeCubicInit initializes the specification structure for image resizing using interpolation with two-parameter cubic filters.
ResizeGetBufferSize Computes the size of the external buffer for image resizing.

ResizeLanczosInit
Initializes the specification structure for image resizing with the Lanczos interpolation method.

Syntax
IppStatus ippiResizeLanczosInit_<mod>(IppiSize srcSize, IppiSize dstSize, Ipp32u numLobes, Ipp32f* pSpec, Ipp8u* pInitBuf);

Supported values for mod:

\begin{array}{cccc}
8u & 16u & 16s & 32f \\
\end{array}

Platform-aware functions
IppStatus ippiResizeLanczosInit_L(IppiSizeL srcSize, IppiSizeL dstSize, IppDataType dataType, Ipp32u numLobes, IppiResizeSpec* pSpec, Ipp8u* pInitBuf);

IppStatus ippiResizeLanczosInit_8u_L(IppiSizeL srcSize, IppiSizeL dstSize, Ipp32u numLobes, IppHintAlgorithm hint, IppiResizeSpec* pSpec, Ipp8u* pInitBuf);

Threading layer (TL) functions
IppStatus ippiResizeLanczosInit_LT(IppiSizeL srcSize, IppiSizeL dstSize, IppDataType dataType, Ipp32u numChannels, Ipp32u numLobes, IppiResizeSpec_LT* pSpec, Ipp8u* pInitBuf);

Include Files
ippi.h

Flavors with the \_LT suffix:ippi_tl.h

Flavors with the \_L suffix:ippi_l.h
Domain Dependencies

Flavors declared in ippi.h:

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:


Parameters

- **srcSize**: Size, in pixels, of the source image.
- **dstSize**: Size, in pixels, of the destination image.
- **dataType**: Data type of the image. Supported values: ipp8u, ipp16u, ipp16s, ipp32f, ipp64f.
- **hint**: Computation algorithm for processing Ipp8u data. Possible values are:
  - ippAlgHintNone: The hint is absent. Equivalent to ippAlgHintFast.
  - ippAlgHintFast: A faster but less accurate algorithm.
  - ippAlgHintAccurate: A slower but more accurate algorithm.
- **numChannels**: Number of image channels. Possible values are 1, 3, or 4.
- **numLobes**: Parameter for Lanczos filters. Possible values are 2 or 3.
- **pSpec**: Pointer to the specification structure for the resize filter.
- **pInitBuf**: Pointer to the temporary buffer for the cubic filter initialization.

Description

This function initializes the specification structure for the resize algorithm with the Lanczos filter interpolation method. This method is based on the 2-lobed or 3-lobed Lanczos window function as an interpolation function, depending on the value of the numLobes parameter.

Before using this function, you need to calculate the size of the specification structure and the external buffer pInitBuf using theippiResizeGetSize function for the corresponding flavor.

NOTE

The function with the parameter hint allows users to choose between a faster but less accurate algorithm and a slower but more accurate one. Without the parameter hint this function initializes the specification structure for the faster but less accurate algorithm for Ipp8u data type.

Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error when one of the specified pointers is NULL.
- **ippStsResizeNoOperation**: Indicates an error when width or height of the image is equal to zero.
Indicates an error when the requested mode is not supported.

Indicates an error if \texttt{dataType} has an illegal value.

Indicates an error if width or height of the source or destination image exceeds 33554431 (0x1FFFFFF) (only for platform-aware and TL functions).

Indicates an error in the following cases:
- If width or height of the source or destination image is negative,
- If the source image size is less than the Lanczos interpolation filter size: 4x4 for the 2-lobed Lanczos function, or 6x6 for the 3-lobed Lanczos function.

**See Also**

*ResizeGetSize* Computes the size of the specification structure and the size of the external temporary buffer for the resize transform initialization.

*ResizeLanczos*

Changes an image size using interpolation with the Lanczos filter.

**Syntax**

\begin{verbatim}
IppStatus ippiResizeLanczos_<mod>(const Ipp<datatype>* pSrc, Ipp32s srcStep, Ipp<datatype>* pDst, Ipp32s dstStep, IppiPoint dstOffset, IppiSize dstSize, IppiBorderType border, const Ipp<datatype>* pBorderValue, const IppiResizeSpec_32f* pSpec, Ipp8u* pBuffer);
\end{verbatim}

Supported values for \texttt{mod}:

\begin{verbatim}
8u_C1R  16u_C1R  16s_C1R  32f_C1R
8u_C3R  16u_C3R  16s_C3R  32f_C3R
8u_C4R  16u_C4R  16s_C4R  32f_C4R
\end{verbatim}

**Platform-aware functions**

\begin{verbatim}
IppStatus ippiResizeLanczos_<mod>_L(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pDst, IppSizeL dstStep, IppiPointL dstOffset, IppSizeL dstSize, IppiBorderType border, const Ipp<datatype>* pBorderValue, const IppiResizeSpec* pSpec, Ipp8u* pBuffer);
\end{verbatim}

Supported values for \texttt{mod}:

\begin{verbatim}
8u_C1R  16u_C1R  16s_C1R  32f_C1R
8u_C3R  16u_C3R  16s_C3R  32f_C3R
8u_C4R  16u_C4R  16s_C4R  32f_C4R
\end{verbatim}
Threading layer (TL) functions

IppStatus ippiResizeLanczos_<mod>_LT(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pDst, IppSizeL dstStep, IppiBorderType border, const Ipp<datatype>* pBorderValue, const IppiResizeSpec_LT* pSpec, Ipp8u* pBuffer);

Supported values for mod:

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R
- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 8u_C4R
- 16u_C4R
- 16s_C4R
- 32f_C4R

Include Files

ippi.h

Flavors with the _LT suffix: ippi_tl.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Flavors declared in ippi.h:

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:


Parameters

- pSrc: Pointer to the source image.
- srcStep: Distance, in bytes, between the starting points of consecutive lines in the source image buffer.
- pDst: Pointer to the destination image.
- dstStep: Distance, in bytes, between the starting points of consecutive lines in the destination image buffer.
- dstOffset: Offset of the tiled destination image with respect to the destination image origin.
- dstSize: Size of the destination image in pixels.
- border: Type of border. Possible values are:

  - ippBorderRepl: Border is replicated from the edge pixels.
  - ippBorderInMem: Border is obtained from the source image pixels in memory.

  Mixed borders are also supported. They can be obtained by the bitwise operation OR between the ippBorderRepl type and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight types.
pBorderValue

Pointer to the constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

pSpec

Pointer to the specification structure for the resize filter.

pBuffer

Pointer to the work buffer.

Description

This function changes an image size using interpolation with the Lanczos filter. The image size can be either reduced or increased in each direction, depending on the destination image size.

This function operates with ROI. It resizes the source image ROI origin to the destination image ROI origin. You need to define the destination image ROI origin by the following parameters: the offset of the tiled destination image with respect to the destination image origin and the destination image size. The source image ROI origin is defined automatically. To obtain the source image ROI, use theippiResizeGetSrcRoi function with the corresponding mod value. To obtain the source image ROI origin offset, call theippiResizeGetSrcOffset function with the corresponding mod value. Parameters pSrc and pDst must point to the processed source and destination image ROI origins, respectively.

The interpolation algorithm applied uses edge pixels of the source image that are out of the image origin. The functionippiResizeLanczos uses in calculation the weighted values of these outer pixels. To obtain the size of the out of the source image origin, call theippiResizeGetBorderSize function for the corresponding flavor.

If the border type is equal to ippBorderRepl, the source image edge pixels are replicated out of the image origin. If the border type is equal to ippBorderInMem, the outer pixels are obtained from the out of the source image origin space. For the mixed border types, a combined approach is applied.

Before using theippiResizeLanczos function, you need to initialize the specification structure using theippiResizeLanczosInit function and compute the size of the external buffer pBuffer using theippiResizeGetBufferSize function for the corresponding flavor.

Return Values

ippiStsNoErr

Indicates no error.

ippiStsNullPtrErr

Indicates an error when one of the specified pointers is NULL.

ippiStsNoOperation

Indicates a warning when width or height of the destination image is equal to zero.

ippiStsBorderErr

Indicates an error when the border value is illegal.

ippiStsContextMatchErr

Indicates an error when pointer to the specification structure is invalid.

ippiStsNotSupportedModeErr

Indicates an error when the requested mode is not supported.

ippiStsSizeErr

Indicates an error when width or height of the destination image is negative.

ippiStsStepErr

Indicates an error when the step value is not data type multiple.

ippiStsOutOfRangeErr

Indicates an error when the destination image offset point is outside the destination image origin.

ippiStsSizeWrn

Indicates a warning when the destination image size is more than the destination image origin size.

See Also

ROI Processing in Geometric Transforms
ResizeGetSrcRoi  Computes the ROI of the source image for resizing by tile processing.
ResizeGetSrcOffset  Computes the offset of the source image for resizing by tile processing.
User-defined Border Types
ResizeGetBorderSize  Computes the size of possible borders for the resize transform.
ResizeLanczosInit  Initializes the specification structure for image resizing with the Lanczos interpolation method.
ResizeGetBufferSize  Computes the size of the external buffer for image resizing.

ResizeSuperInit
Initializes the specification structure for image resizing with the super sampling interpolation method.

Syntax
IppStatus ippiResizeSuperInit_<mod>(IppiSize srcSize, IppiSize dstSize,
IppiResizeSpec_32f* pSpec);

Supported values for mod:

8u   16u   16s   32f

Platform-aware function
IppStatus ippiResizeSuperInit_L(IppiSizeL srcSize, IppiSizeL dstSize, IppDataType
dataType, IppiResizeSpec* pSpec);

Threading layer (TL) function
IppStatus ippiResizeSuperInit_LT(IppiSizeL srcSize, IppiSizeL dstSize, IppDataType
dataType, Ipp32u numChannels, IppiResizeSpec_LT* pSpec);

Include Files
ippi.h

Flavors with the _LT suffix: ippi_tl.h
Flavors with the _L suffix: ippi_l.h

Domain Dependencies
Flavors declared in ippi.h:
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
Flavors declared in ippi_tl.h:

Parameters
srcSize  Size, in pixels, of the source image.
dstSize  Size, in pixels, of the destination image.
dataType  Data type of the image. Supported values: ipp8u, ipp16u, ipp16s, ipp32f, ipp64f.
pSpec    Pointer to the specification structure for the resize filter.
numChannels  Number of channels. Possible values are 1, 3, and 4.
Description
This function initializes the specification structure for the resize algorithm with the super sampling interpolation method. To calculate the size of the specification structure, call the ippiResizeGetSize function.

Return Values
- **ippStsNoErr** Indicates no error.
- **ippStsNullPtrErr** Indicates an error if one of the specified pointers is NULL.
- **ippStsNoOperation** Indicates a warning if width or height of the image is equal to zero.
- **ippStsSizeErr** Indicates an error in the following cases:
  - Indicates that one of the specified dimensions of the source image is less than the corresponding dimension of the destination image, or that the width or height of the source or destination image is negative.
  - If the width or height of the source or destination image is negative.
- **ippStsExceededSizeErr** Indicates an error If width or height of the source or destination image exceeds 33554431 (0x1FFFFFFF) (only for platform-aware and TL functions).
- **ippStsDataTypeErr** Indicates an error if dataType has an illegal value.

See Also
ResiGetSize  Computes the size of the specification structure and the size of the external temporary buffer for the resize transform initialization.

ResizeSuper
Changes an image size using the super sampling interpolation method.

Syntax
```c
IppStatus ippiResizeSuper_<mod>(const Ipp<datatype>* pSrc, Ipp32s srcStep, Ipp<datatype>* pDst, Ipp32s dstStep, IppiPoint dstOffset, IppiSize dstSize, const IppiResizeSpec_32f* pSpec, Ipp8u* pBuffer);
```

Supported values for mod:
- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R
- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 8u_C4R
- 16u_C4R
- 16s_C4R
- 32f_C4R
Platform-aware functions

IppStatus ippiResizeSuper_<mod>_L(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pDst, IppSizeL dstStep, IppiPointL dstOffset, IppSizeL dstSize, const IppiResizeSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R
- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 8u_C4R
- 16u_C4R
- 16s_C4R
- 32f_C4R

Threading layer (TL) functions

IppStatus ippiResizeSuper_<mod>_LT(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pDst, IppSizeL dstStep, const IppiResizeSpec_LT* pSpec, Ipp8u* pBuffer);

Supported values for mod:

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R
- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 8u_C4R
- 16u_C4R
- 16s_C4R
- 32f_C4R

Include Files

ippi.h

Flavors with the _LT suffix: ippi_tl.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Flavors declared in ippi.h:

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:


Parameters

- pSrc: Pointer to the source image.
- srcStep: Distance, in bytes, between the starting points of consecutive lines in the source image buffer.
- pDst: Pointer to the destination image.
- dstStep: Distance, in bytes, between the starting points of consecutive lines in the destination image buffer.
- dstOffset: Offset of the tiled destination image with respect to the destination image origin.
- dstSize: Size of the destination image in pixels.
$p$Spec

$\text{Pointer to the specification structure for the resize filter.}$

$pBuffer$

$\text{Pointer to the work buffer.}$

**Description**
This function changes an image size using the super sampling interpolation method. This method only reduces the image size.

This function operates with ROI. It resizes the source image ROI origin to the destination image ROI origin. You need to define the destination image ROI origin by the following parameters: the offset of the tiled destination image with respect to the destination image origin and the destination image size. The source image ROI origin is defined automatically. To obtain the source image ROI, use the *ippiResizeGetSrcRoi* function with the corresponding *mod* value. To obtain the source image ROI origin offset, call the *ippiResizeGetSrcOffset* function with the corresponding *mod* value. Parameters $pSrc$ and $pDst$ must point to the processed source and destination image ROI origins, respectively.

The interpolation algorithm applied uses only pixels of the source image origin that are inside of the image boundaries.

Before using the *ippiResizeLinear* function, you need to initialize the resize structure using the *ippiResizeSuperInit* function and compute the size of the external buffer $pBuffer$ using the *ippiResizeGetBufferSize* function for the corresponding flavor.

**NOTE**
You can get better performance if you use the following scaling factors along the $x$ and $y$ axes: $1/2, 2/3, 3/4, 4/5, 5/6, 8/9, 1/3, 2/5, 3/5, 3/7, 4/9, 7/10, 1/4, 2/7, 3/8, 1/8$.

**Return Values**

- *ippStsNoErr*: Indicates no error.
- *ippStsNullPtrErr*: Indicates an error when one of the specified pointers is *NULL*.
- *ippStsNoOperation*: Indicates a warning when width or height of the destination image is equal to zero.
- *ippStsContextMatchErr*: Indicates an error when pointer to the spec structure is invalid.
- *ippStsStepErr*: Indicates an error when the step value is not data type multiple.
- *ippStsOutOfRangeErr*: Indicates an error when the destination image offset point is outside the destination image origin.
- *ippStsSizeWrn*: Indicates a warning when the destination image size is more that the destination image origin size.

**See Also**

- **ROI Processing in Geometric Transforms**
- *ResizeGetSrcRoi*: Computes the ROI of the source image for resizing by tile processing.
- *ResizeGetSrcOffset*: Computes the offset of the source image for resizing by tile processing.
- *ResizeSuperInit*: Initializes the specification structure for image resizing with the super sampling interpolation method.
- *ResizeGetBufferSize*: Computes the size of the external buffer for image resizing.
**ResizeAntialiasingLinearInit**  
*Initializes the specification structure for image resizing with antialiasing using linear interpolation.*

**Syntax**

IppStatus ippiResizeAntialiasingLinearInit(IppSize srcSize, IppSize dstSize, IppiResizeSpec_32f* pSpec, Ipp8u* pInitBuf);

**Platform-aware function**

IppStatus ippiResizeAntialiasingLinearInit_L(IppSizeL srcSize, IppSizeL dstSize, IppDataType dataType, IppiResizeSpec* pSpec, Ipp8u* pInitBuf);

**Threading layer (TL) function**

IppStatus ippiResizeAntialiasingLinearInit_LT(IppSizeL srcSize, IppSizeL dstSize, IppDataType dataType, Ipp32u numChannels, IppiResizeSpec_LT* pSpec, Ipp8u* pInitBuf);

**Include Files**

ippi.h

Flavors with the _LT suffix: ippi_tl.h  
Flavors with the _L suffix: ippi_l.h

**Domain Dependencies**

Flavors declared in ippi.h:

Headers: ippcore.h, ippvm.h, ipps.h  
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:


**Parameters**

- **srcSize**: Size of the source image, in pixels.
- **dstSize**: Size of the destination image, in pixels.
- **dataType**: Data type of the image. Supported values: ipp8u, ipp16u, ipp16s, ipp32f, ipp64f.
- **numChannels**: Number of image channels. Possible values: 1, 3, or 4.
- **pSpec**: Pointer to the specification structure for the resize filter.
- **pInitBuf**: Pointer to the temporary buffer for initialization of the linear filter.

**Description**

This function initializes the IppiResizeSpec_32f structure for the resize operation with antialiasing using the linear interpolation method.

Before using this function, calculate the size of the temporary buffer and specification structure using the ippiResizeGetSize function with the antialiasing parameter equal to 1.
### Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error when one of the specified pointers is `NULL`.
- **ippStsNoOperation**: Indicates a warning when width or height of the image is equal to zero.
- **ippStsSizeErr**: Indicates an error if width or height of the source or destination image is negative.
- **ippStsExceededSizeErr**: Indicates an error if width or height of the source or destination image exceeds 33554431 (0x1FFFFFF).
- **ippStsDataTypeErr**: Indicates an error if `dataType` has an illegal value.

### See Also

- **ResizeGetSize**: Computes the size of the specification structure and the size of the external temporary buffer for the resize transform initialization.
- **Linear Interpolation**

### ResizeAntialiasingCubicInit

*Initializes the specification structure for image resizing with antialiasing using interpolation with the two-parameter cubic filters.*

### Syntax

**Platform-aware function**

```c
IppStatus ippiResizeAntialiasingCubicInit(IppiSize srcSize, IppiSize dstSize, Ipp32f valueB, Ipp32f valueC, IppiResizeSpec_32f* pSpec, Ipp8u* pInitBuf);
```

**Threading layer (TL) function**

```c
IppStatus ippiResizeAntialiasingCubicInit_LT(IppiSize srcSize, IppiSize dstSize, IppDataType dataType, Ipp32f valueB, Ipp32f valueC, IppiResizeSpec_LT* pSpec, Ipp8u* pInitBuf);
```

### Include Files

- `ippi.h`

  Flavors with the `_LT` suffix: `ippi_t1.h`

  Flavors with the `_L` suffix: `ippi_l.h`

### Domain Dependencies

- **Flavors declared in `ippi.h`**:
  - **Headers**: `ippcore.h`, `ippvm.h`, `ipps.h`
  - **Libraries**: `ippcore.lib`, `ippvm.lib`, `ipps.lib`

- **Flavors declared in `ippi_t1.h`**:
  - **Libraries**: `ippcore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`, `ippcore_t1.lib`, `ippi_t1.lib`
Parameters

- **srcSize**: Size of the source image, in pixels.
- **dstSize**: Size of the destination image, in pixels.
- **valueB**: The first parameter for cubic filters.
- **valueC**: The second parameter for cubic filters.
- **numChannels**: Number of image channels. Possible values: 1, 3, or 4.
- **dataType**: Data type of the image. Supported values: ipp8u, ipp16u, ipp16s, ipp32f, ipp64f.
- **pSpec**: Pointer to the specification structure for the resize filter.
- **pInitBuf**: Pointer to the temporary buffer for initialization of the cubic filter.

Description

This function initializes the `IppiResizeSpec_32f` structure for the resize operation with antialiasing using interpolation with the two-parameter cubic filters.

Before using this function, calculate the size of the temporary buffer and specification structure using the `ippiResizeGetSize` function with the `antialiasing` parameter equal to 1.

Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error when one of the specified pointers is NULL.
- **ippStsNoOperation**: Indicates a warning when width or height of the image is equal to zero.
- **ippStsSizeErr**: Indicates an error if width or height of the source or destination image is negative.
- **ippStsExceededSizeErr**: Indicates an error if width or height of the source or destination image exceeds 33554431 (0x1FFFFFF) (only for platform-aware and TL functions).
- **ippStsDataTypeErr**: Indicates an error if `dataType` has an illegal value.

See Also

- **ResizeGetSize**: Computes the size of the specification structure and the size of the external temporary buffer for the resize transform initialization.
- **Cubic Interpolation**
- **ResizeAntialiasingLanczosInit**: Initializes the specification structure for image resizing with antialiasing using interpolation with the Lanczos filter.

Syntax

```
IppStatus ippiResizeAntialiasingLanczosInit(IppiSize srcSize, IppiSize dstSize, Ipp32u numLobes, IppiResizeSpec_32f* pSpec, Ipp8u* pInitBuf);
```
Platform-aware function

```c
IppStatus ippiResizeAntialiasingLanczosInit_L(IppiSizeL srcSize, IppiSizeL dstSize,
    IppDataType dataType, Ipp32u numLobes, IppiResizeSpec* pSpec, Ipp8u* pInitBuf);
```

Threading layer (TL) function

```c
IppStatus ippiResizeAntialiasingLanczosInit_LT(IppiSizeL srcSize, IppiSizeL dstSize,
    IppDataType dataType, Ipp32u numChannels, Ipp32u numLobes, IppiResizeSpec_LT* pSpec,
    Ipp8u* pInitBuf);
```

Include Files

ippi.h

Flavors with the _LT suffix: ippi_tl.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Flavors declared in ippi.h:

- Headers: ippcore.h, ippvm.h, ipps.h
- Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:


Parameters

- `srcSize` Size of the source image, in pixels.
- `dstSize` Size of the destination image, in pixels.
- `numLobes` Number of lobes for the Lanczos window. Possible values: 2 or 3.
- `numChannels` Number of image channels. Possible values: 1, 3, or 4.
- `dataType` Data type of the image. Supported values: ipp8u, ipp16u, ipp16s, ipp32f, ipp64f.
- `pSpec` Pointer to the specification structure for the resize filter.
- `pInitBuf` Pointer to the temporary buffer for initialization of the cubic filter.

Description

This function initializes the IppiResizeSpec_32f structure for the resize operation with antialiasing using interpolation with the Lanczos filter. The Lanczos interpolation method is based on the 2-lobed or 3-lobed Lanczos window function as an interpolation function depending on the value of the `numLobes` parameter.

Before using this function, calculate the size of the temporary buffer and specification structure using the `ippiResizeGetSize` function with the antialiasing parameter equal to 1.

Return Values

- `ippStsNoErr` Indicates no error.
- `ippStsNullPtrErr` Indicates an error when one of the specified pointers is NULL.
ippStsNoOperation
Indicates a warning when width or height of the image is equal to zero.

ippStsSizeErr
Indicates an error if width or height of the source or destination image is negative.

ippStsExceededSizeErr
Indicates an error if width or height of the source or destination image exceeds 33554431 (0x1FFFFFF) (only for platform-aware and TL functions).

ippStsDataTypeErr
Indicates an error if \texttt{dataType} has an illegal value.

See Also
ResizeGetSize Computes the size of the specification structure and the size of the external temporary buffer for the resize transform initialization.

\textbf{Lanczos Interpolation}

\textbf{ResizeAntialiasing}

\textit{Changes an image size using the chosen interpolation method with antialiasing.}

\textbf{Syntax}

\texttt{IppStatus ippiResizeAntialiasing\_{<data\_type>\_<chan>}(const Ipp\_{<data\_type>\_pSrc, Ipp32s srcStep, Ipp\_{<data\_type>\_pDst, Ipp32s dstStep, IppiPoint dstOffset, IppiSize dstSize, IppiBorderType border, const Ipp\_{<data\_type>\_pBorderValue, const IppiResizeSpec\_{\_32f\_pSpec, Ipp8u* pBuffer};}

Supported values for \texttt{data\_type}:

\begin{tabular}{cccc}
  8u & 16u & 16s & 32f \\
\end{tabular}

Supported values for \texttt{chan}:

\begin{tabular}{ccc}
  C1R & C3R & C4R \\
\end{tabular}

\textbf{Platform-aware functions}

\texttt{IppStatus ippiResizeAntialiasing\_{<data\_type>\_<chan>\_L(const Ipp\_{<data\_type>\_pSrc, IppSizeL srcStep, Ipp\_{<data\_type>\_pDst, IppSizeL dstStep, IppPointL dstOffset, IppSizeL dstSize, IppiBorderType border, const Ipp\_{<data\_type>\_pBorderValue, const IppiResizeSpec\_{\_32f\_pSpec, Ipp8u* pBuffer});}

Supported values for \texttt{data\_type}:

\begin{tabular}{cccc}
  8u & 16u & 16s & 32f \\
\end{tabular}

Supported values for \texttt{chan}:

\begin{tabular}{ccc}
  C1R & C3R & C4R \\
\end{tabular}
Threading layer (TL) functions

IppStatusippiResizeAntialiasing_<data_type>_<chan>_LT(const Ipp<data_type>* pSrc, IppSizeL srcStep, Ipp<data_type>* pDst, IppSizeL dstStep, IppBorderType border, const Ipp<data_type>* pBorderValue, const IppiResizeSpec_LT* pSpec, Ipp8u* pBuffer);

Supported values for data_type:

8u  16u  16s  32f

Supported values for chan:

C1R  C3R  C4R

Include Files

ippi.h

Flavors with the _LT suffix: ippi_tl.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Flavors declared in ippi.h:

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Flavors declared in ippi_tl.h:


Parameters

pSrc

Pointer to the source image.

srcStep

Distance, in bytes, between the starting points of consecutive lines in the source image buffer.

pDst

Pointer to the destination image.

dstStep

Distance, in bytes, between the starting points of consecutive lines in the destination image buffer.

dstOffset

Offset of the tiled destination image with respect to the destination image origin.

dstSize

Size of the destination image, in pixels.

border

Type of border. Possible values are:

ippBorderRepl  Border is replicated from the edge pixels.
ippBorderConst  Border pixels are set to constants.
ippBorderInMem  Border is obtained from the source image pixels in memory.
Mixed borders are also supported. They can be obtained by the bitwise operation OR between the ippBorderRepl type and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight types.

**pBorderValue**

Pointer to the constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

**pSpec**

Pointer to the specification structure for the resize filter.

**pBuffer**

Pointer to the external buffer.

**Description**

The ippiResizeAntialiasing function changes the size of an image using the chosen interpolation method with antialiasing. The interpolation method to be applied is defined by the function that you use for the resize filter initialization. Use this function to reduce the image size with minimization of moire artifacts. For more information about the implemented algorithm, refer to [SCH92].

If you use ippiResizeAntialiasing to increase the image size, the function applies the same algorithm as one of the following resize functions, depending on the interpolation type chosen at the initialization stage: ippiResizeLinear, ippiResizeCubic, or ippiResizeLanczos.

This function operates with ROI. It resizes the source image ROI origin to the destination image ROI origin. Define the destination image ROI origin by the following parameters: the offset of the tiled destination image with respect to the destination image origin and the destination image size. The source image ROI origin is defined automatically. To obtain the source image ROI, use the corresponding flavor of the ippiResizeGetSrcRoi function. To obtain the source image ROI origin offset, call the corresponding flavor of the ippiResizeGetSrcOffset function. Parameters pSrc and pDst must point to the processed source and destination image ROI origins, respectively.

The interpolation algorithm applied uses edge pixels of the source image that are out of the image origin. The ippiResizeAntialiasing function uses the weighted values of these outer pixels. To obtain the size of the out of the source image origin, call the corresponding flavor of the ippiResizeGetBorderSize function.

Before using the ippiResizeAntialiasing function, you need to initialize the IppiResizeSpec_32f structure using one of the following functions, depending on the interpolation method to be applied: ippiResizeAntialiasingLinearInit, ippiResizeAntialiasingCubicInit, or ippiResizeAntialiasingLanczosInit, and compute the size of the external buffer pBuffer using the corresponding flavor of the ippiResizeGetBufferSize function.

For more information about the supported border types, see User-defined Border Types.

**Return Values**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error when one of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsNoOperation</td>
<td>Indicates a warning when width or height of the destination image is equal to zero.</td>
</tr>
<tr>
<td>ippStsBorderErr</td>
<td>Indicates an error when the border value is illegal.</td>
</tr>
<tr>
<td>ippStsContextMatchErr</td>
<td>Indicates an error when a pointer to the specification structure is invalid.</td>
</tr>
<tr>
<td>ippStsNotSupportedModeErr</td>
<td>Indicates an error when the requested mode is not supported.</td>
</tr>
</tbody>
</table>
ippiStsSizeErr Indicates an error when width or height of the destination image is negative.

ippiStsStepErr Indicates an error when the step value is not data type multiple.

ippiStsOutOfRangeErr Indicates an error when the destination image offset point is outside the destination image origin.

ippiStsSizeWrn Indicates a warning when the destination image size is more than the destination image origin size.

Example
To better understand usage of theippiResizeAntialiasing function, refer to theResizeAntialiasing.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

The figure below demonstrates the results of reducing a 1751x1044 image by five times with antialiasing (a) and without (b).

See Also
ROI Processing in Geometric Transforms
User-defined Border Types
ResizeGetSrcRoi Computes the ROI of the source image for resizing by tile processing.
ResizeGetSrcOffset Computes the offset of the source image for resizing by tile processing.
ResizeGetBorderSize Computes the size of possible borders for the resize transform.
ResizeGetBufferSize Computes the size of the external buffer for image resizing.
ResizeAntialiasingLinearInit Initializes the specification structure for image resizing with antialiasing using linear interpolation.
ResizeAntialiasingCubicInit Initializes the specification structure for image resizing with antialiasing using interpolation with the two-parameter cubic filters.
ResizeAntialiasingLanczosInit Initializes the specification structure for image resizing with antialiasing using interpolation with the Lanczos filter.

ResizeFilterGetSize
Calculates the size of the state structure for resizing filter.

Syntax
IppStatus ippiResizeFilterGetSize_8u_C1R(IppiSize srcRoiSize, IppiSize dstRoiSize, IppiResizeFilterType filter, Ipp32u* pSize);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

- `srcRoiSize`: Size of the source image ROI in pixels.
- `dstRoiSize`: Size of the destination image ROI in pixels.
- `filter`: Type of filter used in resizing; possible values: `ippResizeFilterHann`, `ippResizeFilterLanczos`.
- `pSize`: Pointer to the size (in bytes) of the state structure.

Description

This function operates with ROI (see ROI Processing in Geometric Transforms).

This function calculates the size `pSize` of the state structure required for the function `ippiResizeFilter`. The type of filter is specified by the parameter `filter`.

Return Values

- `ippStsNoErr`: Indicates no error. Any other value indicates an error.
- `ippStsNullPtrErr`: Indicates an error condition if the `pSize` pointer is `NULL`.
- `ippStsSizeErr`: Indicates an error condition if `srcRoiSize` or `dstRoiSize` has a field with zero or negative value.
- `ippStsNotSupportedModeErr`: Indicates an error condition if `filter` has an invalid value.

ResizeFilterInit

*Initializes the state structure for the resize filter.*

Syntax

```c
IppStatus ippiResizeFilterInit_8u_C1R(IppiResizeFilterState* pState, IppiSize srcRoiSize, IppiSize dstRoiSize, IppiResizeFilterType filter);
```

Include Files

`ippi.h`

Domain Dependencies

Headers: `ippcore.h`, `ippvm.h`, `ipps.h`

Libraries: `ippcore.lib`, `ippvm.lib`, `ipps.lib`

Parameters

- `pState`: Pointer to the state structure for resize filter.
- `srcRoiSize`: Size of the source image ROI in pixels.
- `dstRoiSize`: Size of the destination image ROI in pixels.
- `filter`: Type of filter used in resizing; possible values: `ippResizeFilterHann`, `ippResizeFilterLanczos`.

Description

This function operates with ROI (see ROI Processing in Geometric Transforms).
This function initializes the state structure `pState` for the resizing filter used by the function `ippiResizeFilter`. The size of the structure must be computed by the function `ippiResizeFilterGetSize` beforehand. The type of filter is specified by the parameter `filter` and it must be the same as in the function `ippiResizeFilterGetSize`.

**Return Values**

- `ippStsNoErr`: Indicates no error. Any other value indicates an error.
- `ippStsNullPtrErr`: Indicates an error condition if the `pState` pointer is `NULL`.
- `ippStsSizeErr`: Indicates an error condition if `srcRoiSize` or `dstRoiSize` has a field with zero or negative value.
- `ippStsNotSupportedModeErr`: Indicates an error condition if `filter` has an invalid value.

**ResizeFilter**

*Changes the size of an image using a generic filter.*

**Syntax**

```c
IppStatus ippiResizeFilter_8u_C1R(const Ipp8u* pSrc, int srcStep, IppiSize srcRoiSize, Ipp8u* pDst, int dstStep, IppiSize dstRoiSize, IppiResizeFilterState* pState);
```

**Include Files**

`ippi.h`

**Domain Dependencies**

**Headers**: `ippcore.h`, `ippvm.h`, `ipps.h`

**Libraries**: `ippcore.lib`, `ippvm.lib`, `ipps.lib`

**Parameters**

- `pSrc`: Pointer to the source image ROI.
- `srcStep`: Distance in bytes between starts of consecutive lines in the source image buffer.
- `srcRoiSize`: Size of the source image ROI in pixels.
- `pDst`: Pointer to the destination image ROI.
- `dstStep`: Distance in bytes between starts of consecutive lines in the destination image buffer.
- `dstRoiSize`: Size of the destination image ROI in pixels.
- `pState`: Pointer to the state structure for the resize filter.

**Description**

This function operates with ROI (see ROI Processing in Geometric Transforms).

This function resizes the source image `pSrc` using the special generic filters. The state structure `pState` contains the parameters of filtering and must be initialized by the function `ippiResizeFilterInit` beforehand.
## Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsStepErr**: Indicates an error condition if `srcStep` or `dstStep` has a zero or negative value.
- **ippStsSizeErr**: Indicates an error condition if `srcRoiSize` or `dstRoiSize` has a field with zero or negative value.
- **ippStsContextMatchErr**: Indicates an error condition if a pointer to an invalid state structure is passed.

## ResizeYUV420GetSize

*Computes sizes of the spec structure and the external buffer for the NV12 resize transform initialization.*

### Syntax

```c
IppStatus ippiResizeYUV420GetSize(IppiSize srcSize, IppiSize dstSize, IppiInterpolationType interpolation, Ipp32u antialiasing, Ipp32s* pSpecSize, Ipp32s* pInitBufSize);
```

### Include Files

- `ippi.h`

### Domain Dependencies

**Headers**: `ippcore.h`, `ippvm.h`, `ipps.h`

**Libraries**: `ippcore.lib`, `ippvm.lib`, `ipps.lib`

### Parameters

- **srcSize**: Size of the source image in pixels.
- **dstSize**: Size of the destination image in pixels.
- **interpolation**: Interpolation method. Supported values are `ippLanczos` and `ippSuper`.
- **antialiasing**: Antialiasing method.
- **pSpecSize**: Pointer to the size in bytes of the spec structure.
- **pInitBufSize**: Pointer to the size in bytes of the temporal buffer.

### Description

This function computes sizes of the spec structure and the external buffer that are required for one of the following functions depending on the interpolation method parameter: `ResizeYUV420LanczosInit` and `ResizeYUV420SuperInit`.

The size of the 2-Lobed Lanczos filter is 8x8.
NOTE
Antialiasing is currently not supported. The value for the antialiasing parameter must be equal to zero.

Return Values

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error condition if one of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsNoOperation</td>
<td>Indicates a warning if width or height of the image is equal to zero.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error in the following cases:</td>
</tr>
<tr>
<td></td>
<td>• if width or height of the image is equal to 1,</td>
</tr>
<tr>
<td></td>
<td>• if the source image size is less than a filter size of the chosen</td>
</tr>
<tr>
<td></td>
<td>interpolation method (except ippSuper),</td>
</tr>
<tr>
<td></td>
<td>• if one of the specified dimensions of the source image is less than</td>
</tr>
<tr>
<td></td>
<td>the corresponding dimension of the destination image (for ippSuper method only),</td>
</tr>
<tr>
<td></td>
<td>• if width or height of the source or destination image is negative,</td>
</tr>
<tr>
<td></td>
<td>• if one of the calculated sizes exceeds maximum 32 bit signed integer</td>
</tr>
<tr>
<td></td>
<td>positive value (the size of the one of the processed images is too large).</td>
</tr>
<tr>
<td>ippStsSizeWrn</td>
<td>Indicates a warning if width or height of the image is odd.</td>
</tr>
<tr>
<td>ippStsInterpolationErr</td>
<td>Indicates an error if interpolation has an illegal value.</td>
</tr>
<tr>
<td>ippStsNoAntialiasing</td>
<td>Indicates a warning if the specified interpolation method does not support antialiasing.</td>
</tr>
<tr>
<td>ippStsNotSupportedModeErr</td>
<td>Indicates an error if the requested mode is currently not supported.</td>
</tr>
</tbody>
</table>

ResizeYUV420GetSrcRoi

Computes the ROI of the source image for NV12 resizing by tile processing.

Syntax

Single precision

IppStatus ippiResizeYUV420GetSrcRoi(const IppiResizeYUV420Spec* pSpec, IppiPoint dstRoiOffset, IppiSize dstRoiSize, IppiPoint* srcRoiOffset, IppiSize* srcRoiSize);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

- **pSpec**: Pointer to the spec structure for the resize filter.
- **dstRoiOffset**: Offset of the tiled destination image ROI.
- **dstRoiSize**: Size of the tiled destination image ROI.
- **srcRoiOffset**: Offset of the source image ROI.
- **srcRoiSize**: Pointer to the size of the source image ROI.

Description

This function computes the ROI of the processed source image using the processed ROI of the destination image for the corresponding resize transform by tile processing. The *pSpec* parameter defines the resize algorithm parameters. Prior to using the `ippiResizeYUV420GetSrcRoi` function, you need to initialize the *pSpec* parameter by calling one of the following functions: `ippiResizeYUV420LanczosInit` or `ippiResizeYUV420SuperInit` functions.

**NOTE**
If the destination ROI size exceeds the image origin, the source ROI will be obtained for an intersection of the destination ROI and image origin.

Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error if one of the specified pointers is NULL.
- **ippStsContextMatchErr**: Indicates an error if pointer to the spec structure is invalid.
- **ippStsOutOfRangeErr**: Indicates an error if the destination image offset point is outside the destination image origin.
- **ippStsMisalignedOffsetErr**: Indicates an error if one of the fields of the **dstRoiOffset** parameter is odd.
- **ippStsSizeErr**: Indicates an error if one of the fields of the **dstRoiSize** is less than 2.
- **ippStsSizeWrn**: Indicates a warning if the destination ROI exceeds the destination image origin or contains odd values.

### ResizeYUV420LanczosInit

*Initializes the spec structure for the NV12 resize transform by interpolation with the Lanczos filter.*

**Syntax**

```c
IppStatus ippiResizeYUV420LanczosInit(IppSize srcSize, IppSize dstSize, Ipp32u numLobes, IppiResizeYUV420Spec* pSpec, Ipp8u* pInitBuf);
```

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

srcSize
Size in pixels of the source image.

dstSize
Size in pixels of the destination image.

numLobes
Parameter for Lanczos filters. Possible values are 2 or 3.

pSpec
Pointer to the spec structure for the resize filter.

pInitBuf
Pointer to the temporal buffer for the cubic filter initialization.

Description

This function initializes the IppiResizeYUV420Spec structure for the resize algorithm with the Lanczos filter interpolation method. This method is based on the 2-lobed or 3-lobed Lanczos window function as an interpolation function depending on the value of the numLobes parameter.

To calculate the size of the spec structure object, call the ippiResizeYUV420GetSize function.

The function ippiResizeYUV420LanczosInit requires the external buffer pInitBuf. Prior to using this function, you need to call ippiResizeYUV420GetSize for the corresponding flavors to compute the size of the buffer.

Return Values

ippiStsNoErr
Indicates no error.

ippiStsNullPtrErr
Indicates an error if one of the specified pointers is NULL.

ippiStsResizeNoOperation
Indicates an error if width or height of the image is equal to zero.

ippiStsSizeWrn
Indicates a warning if width or height of the image is odd.

ippiStsSizeErr
Indicates an error in the following cases:
  • if width or height of the source or destination image is equal to 1,
  • if width or height of the source or destination image is negative,
  • if the source image size is less than the Lanczos interpolation filter size: 8x8 for 2-lobed Lanczos function, or 12x12 for 3-lobed Lanczos function.

ippiStsNotSupportedModeErr
Indicates an error if the requested mode is not supported.

ResizeYUV420SuperInit

Initializes the spec structure for the NV12 resize transform by interpolation with the super sampling algorithm.

Syntax

IppStatus ippiResizeYUV420SuperInit(IppiSize srcSize, IppiSize dstSize, IppiResizeYUV420Spec* pSpec);

Include Files

ippi.h
Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
srcSize  
Size in pixels of the source image.
dstSize  
Size in pixels of the destination image.
pSpec  
Pointer to the spec structure for the resize filter.

Description
This function initializes the IppiResizeYUV420Spec structure for the resize algorithm using interpolation with the super sampling algorithm.
To calculate the size of the spec structure object, call theippiResizeYUV420GetSize function.

Return Values
ippStsNoErr  
Indicates no error.
ippStsNullPtrErr  
Indicates an error if one of the specified pointers is NULL.
ippStsResizeNoOperation  
Indicates an error if width or height of the image is equal to zero.
ippStsSizeWrn  
Indicates a warning if width or height of the image is odd.
ippStsSizeErr  
Indicates an error in the following cases:
- if width or height of the image is equal to 1,
- if one of the specified dimensions of the source image is less than the corresponding dimension of the destination image,
- if width or height of the source or destination image is negative.

ResizeYUV420GetBorderSize
Computes the size of possible borders for the NV12 resize transform.

Syntax
IppStatus ippiResizeYUV420GetBorderSize(const IppiResizeYUV420Spec* pSpec, IppiBorderSize* borderSize);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pSpec  
Pointer to the spec structure for the resize filter.
**borderSize**

Size in pixels of necessary borders.

**Description**

This function computes the size of the source image ROI that is used by the corresponding resize transform and is out of the processing boundaries for Luma and Chroma planes. The \texttt{pSpec} parameter defines the resize algorithm parameters. Prior to using the \texttt{ippiResizeYUV420GetBorderSize} function, you need to initialize the \texttt{pSpec} parameter by calling one of the following functions: \texttt{ippiResizeYUV420LanczosInit} or \texttt{ippiResizeYUV420SuperInit}.

**NOTE**

The returned border size is in Luma/Chroma plane pixels. This means that the chosen resize algorithm uses the returned outer size of the source image ROI for each plane.

**Return Values**

- \texttt{ippStsNoErr} Indicates no error.
- \texttt{ippStsNullPtrErr} Indicates an error if one of the specified pointers is NULL.
- \texttt{ippStsContextMatchErr} Indicates an error if pointer to the spec structure is invalid.

**ResizeYUV420GetSrcOffset**

*Computes the offset of the source image for the NV12 resize transform by tile processing.*

**Syntax**

\[
\text{IppStatus ippiResizeYUV420GetSrcOffset(const IppiResizeYUV420Spec* pSpec, IppiPoint dstOffset, IppiPoint* srcOffset);}\]

**Include Files**

\[
\text{ippi.h}\]

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- \texttt{pSpec} Pointer to the spec structure for the resize filter.
- \texttt{dstOffset} Offset of the tiled destination image with respect to the destination image origin.
- \texttt{srcOffset} Offset of the source image.

**Description**

This function computes the offset of the processed source image ROI using the offset of the processed destination image ROI for the corresponding resize transform by tile processing. The \texttt{pSpec} parameter defines the resize algorithm parameters. Prior to using the \texttt{ippiResizeGetSrcOffset} function, you need to initialize the \texttt{pSpec} parameter by calling one of the following functions: \texttt{ippiResizeYUV420LanczosInit} and \texttt{ippiResizeYUV420SuperInit}.
Return Values

ippStsNoErr  Indicates no error.
ippStsNullPtrErr  Indicates an error if one of the specified pointers is NULL.
ippStsOutOfRangeErr  Indicates an error if the destination image offset point is outside the destination image origin.
ippStsContextMatchErr  Indicates an error if pointer to the spec structure is invalid.
ippStsMisalignedOffsetErr  Indicates an error if one of the fields of the dstOffset parameter is odd.

ResizeYUV420GetBufferSize

Computes the size of the external buffer for the NV12 resize transform.

Syntax

IppStatus ippiResizeYUV420GetBufferSize(const IppiResizeYUV420Spec* pSpec, IppiSize dstSize, Ipp32s* pBufSize);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSpec  Pointer to the spec structure for the resize filter.
dstSize  Size in pixels of the destination image.
pBufSize  Pointer to the size in bytes of the external buffer.

Description

This function computes the size of the external buffer for the NV12 resize transform. The pSpec parameter defines the resize algorithm parameters. Prior to using the ippiResizeYUV420GetBufferSize function, you need to initialize the pSpec parameter by calling one of the following functions: ippiResizeYUV420LanczosInit and ippiResizeYUV420SuperInit.

Return Values

ippStsNoErr  Indicates no error.
ippStsNullPtrErr  Indicates an error if pBufferSize pointer is NULL.
ippStsOutOfRangeErr  Indicates a warning if width or height of the destination image is equal to zero.
ippStsContextMatchErr  Indicates an error if pointer to the spec structure is invalid.
ippStsSizeWrn  Indicates a warning in the following cases:
if width or height of the image is odd,
- if the destination image size is more than the destination image origin size.

`ippStsSizeErr` Indicates an error in the following cases:
- if width or height of the image is equal to 1,
- if width or height of the destination image is negative,
- if the calculated buffer size exceeds maximum 32 bit signed integer positive value (the processed image size is too large).

**ResizeYUV420Lanczos**

*Changes the size of the NV12 image by interpolation with the Lanczos filter.*

**Syntax**

```c
IppStatus ippiResizeYUV420Lanczos_8u_P2R(const Ipp8u* pSrcY, Ipp32s srcYStep, const Ipp8u* pSrcUV, Ipp32s srcUVStep, Ipp8u* pDstY, Ipp32s dstYStep, Ipp8u* pDstUV, Ipp32s dstUVStep, IppiPoint dstOffset, IppiSize dstSize, IppiBorderType border, const Ipp8u* pBorderValue, const IppiResizeYUV420Spec* pSpec, Ipp8u* pBuffer);
```

**Include Files**

`ippi.h`

**Domain Dependencies**

**Headers**: `ippcore.h`, `ippvm.h`, `ipps.h`

**Libraries**: `ippi.lib`, `ippvm.lib`, `ipps.lib`

**Parameters**

- `pSrcY` Pointer to the source image Y plane.
- `srcYStep` Distance in bytes between starts of consecutive lines in the source image Y plane.
- `pSrcUV` Pointer to the source image UV plane.
- `srcUVStep` Distance in bytes between starts of consecutive lines in the source image UV plane.
- `pDstY` Pointer to the destination image Y plane.
- `dstYStep` Distance in bytes between starts of consecutive lines in the destination image Y plane.
- `pDstUV` Pointer to the destination image UV plane.
- `dstUVStep` Distance in bytes between starts of consecutive lines in the destination image UV plane.
- `dstOffset` Offset of the tiled destination image with respect to the destination image origin.
- `dstSize` Size of the destination image in pixels.
- `border` Type of the border.
pBorderValue

Pointer to the constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

pSpec

Pointer to the spec structure for the resize filter.

pBuffer

Pointer to the work buffer.

Description

This function changes an image size using interpolation with the Lanczos filter. The image size can be either reduced or increased in each direction, depending on the destination image size.

This function operates with ROI (see ROI Processing in Geometric Transforms). It resizes the source image ROI origin to the destination image ROI origin. The destination image ROI origin must be defined by the following parameters: the offset of the tiled destination image with respect to the destination image origin and the destination image size. The source image ROI origin is defined automatically. To obtain the source image ROI origin offset, call the ippiResizeYUV420GetSrcOffset function. Parameters pSrcY, pSrcUV and pDstY, pDstUV must point to the processed source and destination image ROI origins respectively.

The source and destination images are in the 4:2:0 two-plane image format (NV12): all Y samples (pSrcY) are found first in memory as an array of unsigned chars with an even number of lines memory alignment, followed by an array (pSrcY) of unsigned chars containing interleaved U and V samples. Supported values for border are ippBorderRepl and ippBorderInMem.

Applied interpolation algorithm uses edge pixels of the source image that are out of the image origin. The function ippiResizeYUV420Lanczos uses in calculation the weighted values of these outer pixels. To obtain the size of the out of the source image origin, call the function ippiResizeYUV420GetBorderSize for the corresponding flavor.

If the border type is equal to ippBorderRepl, the source image edge pixels are replicated out of the image origin. If the border type is equal to ippBorderInMem, the outer pixels are obtained from the out of the source image origin space. For the mixed border types, the combined approach is applied.

Prior to using the ippiResizeLinear function, initialize the IppiResizeYUV420Spec structure by calling the ippiResizeYUV420LanczosInit and compute the size of the external buffer pBuffer by calling the ippiResizeYUV420GetBufferSize for the corresponding flavor.

Return Values

ippStsNoErr
Indicates no error.

ippStsNullPtrErr
Indicates an error if one of the specified pointers is NULL.

ippStsNoOperation
Indicates a warning if width or height of the destination image is equal to zero.

ippStsBorderErr
Indicates an error if the border value is illegal.

ippStsContextMatchErr
Indicates an error if pointer to the spec structure is invalid.

ippStsMisalignedOffsetErr
Indicates an error if one of the fields of the dstOffset parameter is odd.

ippStsSizeWrn
Indicates a warning in the following cases:

- if width of the image is odd,
- if the destination image size is more than the destination image origin.
ippStsSizeErr
Indicates an error if width of the destination image is equal to 1, or if width or height of the source or destination image is negative.

ippStsOutOfRangeErr
Indicates an error if the destination image offset point is outside the destination image origin.

ippStsNotSupportedModeErr
Indicates an error if the requested mode is not supported.

ResizeYUV420Super
Changes the size of the NV12 image by the super sampling interpolation method.

Syntax
IppStatus ippiResizeYUV420Super_8u_P2R(const Ipp8u* pSrcY, Ipp32s srcYStep, const Ipp8u* pSrcUV, Ipp32s srcUVStep, Ipp8u* pDstY, Ipp32s dstYStep, Ipp8u* pDstUV, Ipp32s dstUVStep, IppiPoint dstOffset, IppiSize dstSize, const IppiResizeYUV420Spec* pSpec, Ipp8u* pBuffer);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

\textbf{pSrcY}  
Pointer to the source image Y plane.

\textbf{srcYStep}  
Distance in bytes between starts of consecutive lines in the source image Y plane.

\textbf{pSrcUV}  
Pointer to the source image UV plane.

\textbf{srcUVStep}  
Distance in bytes between starts of consecutive lines in the source image UV plane.

\textbf{pDstY}  
Pointer to the destination image Y plane.

\textbf{dstYStep}  
Distance in bytes between starts of consecutive lines in the destination image Y plane.

\textbf{pDstUV}  
Pointer to the destination image UV plane.

\textbf{dstUVStep}  
Distance in bytes between starts of consecutive lines in the destination image UV plane.

\textbf{dstOffset}  
Offset of the tiled destination image with respect to the destination image origin.

\textbf{dstSize}  
Size of the destination image in pixels.

\textbf{pSpec}  
Pointer to the spec structure for the resize filter.

\textbf{pBuffer}  
Pointer to the work buffer.
Description

This function changes an image size using interpolation with the super sampling algorithm. The image size can be either reduced or increased in each direction, depending on the destination image size.

This function operates with ROI (see ROI Processing in Geometric Transforms). It resizes the source image ROI origin to the destination image ROI origin. The destination image ROI origin must be defined by the following parameters: the offset of the tiled destination image with respect to the destination image origin and the destination image size. The source image ROI origin is defined automatically. To obtain the source image ROI origin offset, call the `ippiResizeYUV420GetSrcOffset` function. Parameters `pSrcY`, `pSrcUV` and `pDstY`, `pDstUV` must point to the processed source and destination image ROI origins respectively.

The interpolation algorithm applied uses only pixels of the source image origin that are inside of the image boundaries.

The source and destination images are in the 4:2:0 two-plane image format (NV12): all Y samples (`pSrcY`) are found first in memory as an array of unsigned chars with an even number of lines memory alignment, followed by an array (`pSrcY`) of unsigned chars containing interleaved U and V samples.

Prior to using the `ippiResizeLinear` function, initialize the `IppiResizeYUV420Spec` structure by calling the `ippiResizeYUV420LanczosInit` and compute the size of the external buffer `pBuffer` by calling the `ippiResizeYUV420GetBufferSize` for the corresponding flavor.

**NOTE**

This function provides optimized code paths for the following scaling factors along the x and y axes: 1/2, 2/3, 3/4, 4/5, 5/6, 8/9, 1/3, 2/5, 3/5, 3/7, 4/9, 7/10, 1/4, 2/7, 3/8, 1/8.

Return Values

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>ippStsNoErr</code></td>
<td>Indicates no error.</td>
</tr>
<tr>
<td><code>ippStsNullPtrErr</code></td>
<td>Indicates an error if one of the specified pointers is NULL.</td>
</tr>
<tr>
<td><code>ippStsNoOperation</code></td>
<td>Indicates a warning if width or height of the destination image is equal to zero.</td>
</tr>
<tr>
<td><code>ippStsBorderErr</code></td>
<td>Indicates an error if the border value is illegal.</td>
</tr>
<tr>
<td><code>ippStsContextMatchErr</code></td>
<td>Indicates an error if pointer to the spec structure is invalid.</td>
</tr>
<tr>
<td><code>ippStsSizeWrn</code></td>
<td>Indicates a warning in the following cases:</td>
</tr>
<tr>
<td></td>
<td>• if width of the image is odd,</td>
</tr>
<tr>
<td></td>
<td>• if the destination image size is more than the destination image origin.</td>
</tr>
<tr>
<td><code>ippStsSizeErr</code></td>
<td>Indicates an error if width or height of the destination image is equal to 1; or if width or height of the source or destination image is negative.</td>
</tr>
<tr>
<td><code>ippStsMisalignedOffsetErr</code></td>
<td>Indicates an error if one of the fields of the <code>dstOffset</code> parameter is odd.</td>
</tr>
<tr>
<td><code>ippStsOutOfRangeErr</code></td>
<td>Indicates an error if the destination image offset point is outside the destination image origin.</td>
</tr>
</tbody>
</table>
**ResizeYUV422GetSize**  
*Computes sizes of the spec structure and the external buffer for YUY2 resize transform initialization.*

**Syntax**

```c
IppStatus ippiResizeYUV422GetSize(IppiSize srcSize, IppiSize dstSize, IppInterpolationType interpolation, Ipp32u antialiasing, Ipp32s* pSpecSize, Ipp32s* pInitBufSize);
```

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **srcSize**  
  Size of the source image in pixels.
- **dstSize**  
  Size of the destination image in pixels.
- **interpolation**  
  Interpolation method. Supported values are ippNearest and ippLinear.
- **antialiasing**  
  Antialiasing method.
- **pSpecSize**  
  Pointer to the size in bytes of the spec structure.
- **pInitBufSize**  
  Pointer to the size in bytes of the temporal buffer.

**Description**

This function computes sizes of the spec structure and the external buffer that are required for one of the following functions depending on the interpolation method parameter: ResizeYUV422NearestInit and ResizeYUV422LinearInit.

The filter sizes of the Nearest Neighbor and Linear interpolation algorithms are 2x1 and 4x2 respectively.

**NOTE**

Antialiasing is currently not supported. The value for the `antialiasing` parameter must be equal to zero.

**Return Values**

- **ippStsNoErr**  
  Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**  
  Indicates an error condition if one of the specified pointers is NULL.
- **ippStsNoOperation**  
  Indicates a warning if width or height of the image is equal to zero.
- **ippStsSizeErr**  
  Indicates an error in the following cases:
• if the source image size is less than the filter size for the chosen interpolation method,
• if one of the calculated sizes exceeds maximum 32 bit signed integer positive value (the size of one of the processed images is too large).

ippStsSizeWrn
Indicates a warning if width of the image is odd.

ippStsInterpolationErr
Indicates an error if interpolation has an illegal value.

ippStsNoAntialiasing
Indicates a warning if the specified interpolation method does not support antialiasing.

ippStsNotSupportedModeErr
Indicates an error if the requested mode is currently not supported.

ResizeYUV422GetBorderSize
*Computes the size of possible borders for the YUY2 resize transform.*

**Syntax**

```c
IppStatus ippiResizeYUV422GetBorderSize(const IppiResizeYUV422Spec* pSpec, IppiBorderSize* borderSize);
```

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **pSpec**: Pointer to the spec structure for the resize filter.
- **borderSize**: Size in pixels of necessary borders.

**Description**

This function computes the size of the source image ROI that is used by the corresponding resize transform and is out of the processing boundaries. The `pSpec` parameter defines the resize algorithm parameters. Prior to using the `ippiResizeYUV422GetBorderSize` function, you need to initialize the `pSpec` parameter by calling one of the following functions: `ippiResizeYUV422NearestInit`, and `ippiResizeYUV422LinearInit`.

**Return Values**

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error if one of the specified pointers is `NULL`.
- **ippStsContextMatchErr**: Indicates an error if pointer to the spec structure is invalid.
ResizeYUV422GetSrcOffset
Computation of the offset of the source image for the YUY2 resize transform by tile processing.

Syntax
IppStatus ippiResizeYUV422GetSrcOffset(const IppiResizeYUV422Spec* pSpec, IppiPoint dstOffset, IppiPoint* srcOffset);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pSpec
Pointer to the spec structure for the resize filter.
dstOffset
Offset of the tiled destination image with respect to the destination image origin.
srcOffset
Offset of the source image.

Description
This function computes the offset of the processed source image ROI using the offset of the processed destination image ROI for the corresponding resize transform by tile processing. The pSpec parameter defines the resize algorithm parameters. Prior to using the ippiResizeYUV422GetSrcOffset function, you need to initialize the pSpec parameter by calling one of the following functions: ippiResizeYUV422NearestInit and ippiResizeYUV422LinearInit.

Return Values
ippStsNoErr
indicates no error.
ippStsNullPtrErr
indicates an error if one of the specified pointers is NULL.
ippStsMisalignedOffsetErr
indicates an error if the x field of the dstOffset parameter is odd.
ippStsOutOfRangeErr
indicates an error if the destination image offset point is outside the destination image origin.
ippStsContextMatchErr
indicates an error if pointer to the spec structure is invalid.

ResizeYUV422GetBufSize
Computes the size of the external buffer for the NV12 resize transform.

Syntax
IppStatus ippiResizeYUV422GetBufSize(const IppiResizeYUV422Spec* pSpec, IppiSize dstSize, Ipp32s* pBufSize);
Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSpec              Pointer to the spec structure for the resize filter.
dstSize            Size in pixels of the destination image.
pBufSize           Pointer to the size in bytes of the external buffer.

Description

This function computes the size of the external buffer for the YUY2 resize transform. The pSpec parameter defines the resize algorithm parameters. Prior to using theippiResizeYUV420GetBufferSize function, you need to initialize the pSpec parameter by calling one of the following functions: ippiResizeYUV422NearestInit and ippiResizeYUV422LinearInit.

Return Values

ippStsNoErr           Indicates no error.
ippStsNullPtrErr      Indicates an error if one of the specified pointers is NULL.
ippStsNoOperation     Indicates a warning if width or height of the destination image is equal to zero.
ippStsContextMatchErr Indicates an error if pointer to the spec structure is invalid.
ippStsSizeWrn         Indicates a warning in the following cases:
                      • if width of the image is odd,
                      • if the destination image size is more than the destination image origin size.
ippStsSizeErr         Indicates an error in the following cases:
                      • if width of the image is equal to 1,
                      • if width or height of the destination image is negative,
                      • if the calculated buffer size exceeds maximum 32 bit signed integer positive value (the processed image size is too large).

ResizeYUV422GetSrcRoi

Computes the ROI of the source image for YUV422 resizing by tile processing.

Syntax

IppStatus ippiResizeYUV422GetSrcRoi(const IppiResizeYUV422Spec* pSpec, IppiPoint dstRoiOffset, IppiSize dstRoiSize, IppiPoint* srcRoiOffset, IppiSize* srcRoiSize);

Include Files

ippi.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSpec**: Pointer to the spec structure for the resize filter.
- **dstRoiOffset**: Offset of the tiled destination image ROI.
- **dstRoiSize**: Size of the tiled destination image ROI.
- **srcRoiOffset**: Offset of the source image ROI.
- **srcRoiSize**: Pointer to the size of the source image ROI.

Description

This function computes the ROI of the processed source image using the processed ROI of the destination image for the corresponding resize transform by tile processing. The `pSpec` parameter defines the resize algorithm parameters. Prior to using the `ippiResizeYUV422GetSrcRoi` function, you need to initialize the `pSpec` parameter by calling one of the following functions: `ippiResizeYUV422NearestInit` or `ippiResizeYUV422LinearInit`.

**NOTE**

If the destination ROI size exceeds the image origin, the source ROI will be obtained for an intersection of the destination ROI and image origin.

Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error if one of the specified pointers is NULL.
- **ippStsContextMatchErr**: Indicates an error if pointer to the specification structure is invalid.
- **ippStsOutOfRangeErr**: Indicates an error if the destination image offset point is outside the destination image origin.
- **ippStsMisalignedOffsetErr**: Indicates an error if x-value of the parameter `dstRoiOffset` is odd.
- **ippStsSizeErr**: Indicates an error in the following cases:
  - If the height of the destination ROI is zero or negative.
  - If the width of the destination ROI is less than 2.
- **ippStsSizeWrn**: Indicates a warning in the following cases:
  - If the width of the destination ROI is odd.
  - If the destination ROI exceeds the destination image origin.

ResizeYUV422NearestInit

Initializes the spec structure for the YUY2 resize transform by the nearest neighbor interpolation method.
Syntax
IppStatus ippiResizeYUV422NearestInit(IppiSize srcSize, IppiSize dstSize, IppiResizeYUV422Spec* pSpec);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

srcSize  Size in pixels of the source image.
dstSize  Size in pixels of the destination image.
pSpec   Pointer to the spec structure for the resize filter.

Description
This function initializes the IppiResizeYUV422Spec structure for the resize algorithm with the nearest neighbor interpolation method. To calculate the size of the spec structure object, call the ippiResizeYUV422GetSize function.

Return Values

ippStsNoErr  Indicates no error.
ippStsNullPtrErr  Indicates an error if one of the specified pointers is NULL.
ippStsNoOperation  Indicates a warning if width or height of the image is equal to zero.
ippStsSizeWrn  Indicates a warning if width of the image is odd.
ippStsSizeErr  Indicates an error if width of the image is equal to 1, or if width or height of the source or destination image is negative.

ResizeYUV422LinearInit
Initializes the spec structure for the YUY2 resize transform by the linear interpolation method.

Syntax
IppStatus ippiResizeYUV422LinearInit(IppiSize srcSize, IppiSize dstSize, IppiResizeYUV422Spec* pSpec);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

- **srcSize**: Size in pixels of the source image.
- **dstSize**: Size in pixels of the destination image.
- **pSpec**: Pointer to the spec structure for the resize filter.

Description

This function initializes the IppiResizeYUV422Spec structure for the resize algorithm with the linear interpolation method. To calculate the size of the spec structure object, call the ippiResizeYUV422GetSize function.

Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error if one of the specified pointers is NULL.
- **ippStsNoOperation**: Indicates a warning if width or height of the image is equal to zero.
- **ippStsSizeWrn**: Indicates a warning if width of the image is odd.
- **ippStsSizeErr**: Indicates an error in the following cases:
  - if width of the image is equal to 1,
  - if width or height of the source or destination image is negative,
  - if the source image size is less than the linear filter size 4x2.

ResizeYUV422Nearest

*Changes an YUY2 image size by the nearest neighbor interpolation method.*

Syntax

```c
IppStatus ippiResizeYUV422Nearest_8u_C2R(const Ipp8u* pSrc, Ipp32s srcStep, Ipp8u* pDst, Ipp32s dstStep, IppiPoint dstOffset, IppiSize dstSize, const IppiResizeYUV422Spec* pSpec, Ipp8u* pBuffer);
```

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc**: Pointer to the source image.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image buffer.
- **pDst**: Pointer to the destination image.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image buffer.
**dstOffset**
Offset of the tiled destination image with respect to the destination image origin.

**dstSize**
Size of the destination image in pixels.

**pSpec**
Pointer to the spec structure for the resize filter.

**pBuffer**
Pointer to the work buffer.

**Description**
This function changes an image size using the nearest neighbor interpolation method. The image size can be either reduced or increased in each direction, depending on the destination image size.

This function operates with ROI (see ROI Processing in Geometric Transforms). It resizes the source image ROI origin to the destination image ROI origin. The destination image ROI origin must be defined by the following parameters: the offset of the tiled destination image with respect to the destination image origin and the destination image size. The source image ROI origin is defined automatically. To obtain the source image ROI origin offset, call the `ippiResizeYUV422GetSrcOffset` function. Parameters `pSrc` and `pDst` must point to the processed source and destination image ROI origins respectively.

The source and destination images are in the YUY2 pixel format (Y0U0Y1V0,Y2U1Y3V1,.. or Y0Cb0Y1Cr0,Y2Cb1Y3Cr1,..).

The interpolation algorithm applied uses only pixels of the source image origin that are inside of the image boundaries.

Prior to using the `ippiResizeYUV422Nearest` function, initialize the `IppiResizeYUV422Spec` structure by calling the `ippiResizeYUV422NearestInit` and compute the size of the external buffer `pBuffer` by calling the `ippiResizeYUV422GetBufSize` for the corresponding flavor.

**Return Values**

- **ippStsNoErr**
  Indicates no error.

- **ippStsNullPtrErr**
  Indicates an error if one of the specified pointers is NULL.

- **ippStsNoOperation**
  Indicates a warning if width or height of the destination image is equal to zero.

- **ippStsContextMatchErr**
  Indicates an error if pointer to the spec structure is invalid.

- **ippStsSizeWrn**
  Indicates a warning in the following cases:
  - if width of the image is odd,
  - if the destination image size is more than the destination image origin.

- **ippStsMisalignedOffsetErr**
  Indicates an error if the x field of the `dstOffset` parameter is odd.

- **ippStsSizeErr**
  Indicates an error if width of the destination image is equal to 1, or if width or height of the source or destination image is negative.

- **ippStsOutOfRangeErr**
  Indicates an error if the destination image offset point is outside the destination image origin.

**ResizeYUV422Linear**
Changes an YUY2 image size by the linear interpolation method.
Syntax
IppStatus ippiResizeYUV422Linear_8u_C2R(const Ipp8u* pSrc, Ipp32s srcStep, Ipp8u* pDst, Ipp32s dstStep, IppiPoint dstOffset, IppiSize dstSize, IppiBorderType border, const Ipp8u* pBorderValue, const IppiResizeYUV422Spec* pSpec, Ipp8u* pBuffer);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pSrc Pointer to the source image.
srcStep Distance in bytes between starts of consecutive lines in the source image buffer.
pDst Pointer to the destination image.
dstStep Distance in bytes between starts of consecutive lines in the destination image buffer.
dstOffset Offset of the tiled destination image with respect to the destination image origin.
dstSize Size of the destination image in pixels.
border Type of the border.
pBorderValue Pointer to the constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.
pSpec Pointer to the spec structure for the resize filter.
pBuffer Pointer to the work buffer.

Description
This function changes an image size using the linear interpolation method. The image size can be either reduced or increased in each direction, depending on the destination image size.

This function operates with ROI (see ROI Processing in Geometric Transforms). It resizes the source image ROI origin to the destination image ROI origin. The destination image ROI origin must be defined by the following parameters: the offset of the tiled destination image with respect to the destination image origin and the destination image size. The source image ROI origin is defined automatically. To obtain the source image ROI origin offset, call the ippiResizeYUV422GetSrcOffset function. The source and destination images are in the YUY2 pixel format (Y0U0Y1V0,Y2U1Y3V1,... or Y0Cb0Y1Cr0,Y2Cb1Y3Cr1,...).

Supported values for border are ippBorderRepl and ippBorderInMem.

The interpolation algorithm applied uses edge pixels of the source image that are out of the ROI. The function ippiResizeYUV422Linear uses the weighted values of these outer pixels in calculation. To obtain the size of the out of the ROI source image, call the function ippiResizeYUV422GetBorderSize.

If the border type is equal to ippBorderRepl, the source image edge pixels are replicated out of the ROI. If the border type is equal to ippBorderInMem, the outer pixels are obtained from the out of the ROI image space.
Prior to using the `ippiResizeYUV422Linear` function, initialize the `IppiResizeYUV422Spec` structure by calling the `ippiResizeYUV422LinearInit` and compute the size of the external buffer `pBuffer` by calling the `ippiResizeYUV422GetBufSize` for the corresponding flavor.

**Return Values**

- `ippStsNoErr`: Indicates no error.
- `ippStsNullPtrErr`: Indicates an error if one of the specified pointers is `NULL`.
- `ippStsNoOperation`: Indicates an error if width or height of the destination image is equal to zero.
- `ippStsBorderErr`: Indicates an error if the `border` value is illegal.
- `ippStsContextMatchErr`: Indicates an error if pointer to the spec structure is invalid.
- `ippStsSizeWrn`: Indicates a warning in the following cases:
  - if width of the destination image is odd,
  - if the destination image size is more than the destination image origin.
- `ippStsMisalignedOffsetErr`: Indicates an error if the `x` field of the `dstOffset` parameter is odd.
- `ippStsSizeErr`: Indicates an error if width of the destination image is equal to 1, or if width or height of the source or destination image is negative.
- `ippStsOutOfRangeErr`: Indicates an error if the destination image offset point is outside the destination image origin.

**Warp Functions with Prior Initialization**

This section describes the Intel® IPP warping functions that use the specification structure in operation. Before using these functions, you need to initialize the structure.

**Using Intel® IPP Warp Affine Functions with Prior Initialization**

You can use one of the following approaches to image warping:

- **Warping the whole image**
- **Warping a tiled image with one prior initialization**

Interpolation algorithms of the Nearest Neighbor, Linear, and Cubic types can use edge pixels of the source image that are out of the image origin. When calling the `ippiWarpAffine<Filter>` function with one of these interpolation algorithms applied, you need to specify the appropriate border type. The following border types are supported:

- Replicated borders: border pixels are replicated from the source image boundary pixels
- Constant border: values of all border pixels are set to a constant
- Transparent borders: destination pixels that have inverse transformed location out of the source image are not processed
- Borders in memory: the source image border pixels are obtained from the source image pixels in memory
- Mixed borders: combination of transparent borders and borders in memory is applied

**Warping the Whole Image**

You can follow the approach described below to apply affine transformation when source and destination images are fully accessible in memory. However, this method only runs on a single thread.

To transform the whole image:
1. Call the `WarpAffineGetSize` function with the appropriate interpolation type. This function uses source and destination image sizes to calculate how much memory must be allocated for the `IppWarpSpec` structure and work buffer.

2. Initialize the `IppWarpSpec` structure by calling the `ippiWarp<Filter>Init`, where `<Filter>` can take one of the following values: Nearest, Linear, and Cubic. These prerequisite steps enable calling the warp functions multiple times without recalculations.

3. Call the `WarpGetBufferSize` function for the initialized `IppWarpSpec` structure. This function uses the destination image size to calculate how much memory must be allocated for the warp work buffer.

4. Call `ippiWarpAffine<Filter>` with the appropriate image type.

5. Specify the algorithm for borders processing by setting the `borderType` and `pBorderValue` parameters when initializing the `IppiWarpSpec` structure. The data type of `pBorderValue` is automatically converted from `Ipp64f` to the data type of the processed images. The function supports the following algorithms for borders processing:
   - If the border type is equal to `ippBorderRepl`, the source image outer pixels are replicated from the edge pixels.
   - If the border type is equal to `ippBorderConst`, the outer pixels are set to the constant value specified in `pBorderValue`.
   - If the border type is equal to `ippBorderTransp`, destination image pixels mapped to the outer source image pixels are not changed. The outer pixels are replicated from the edge pixels, if they are required by interpolation algorithm.
   - If the border type is equal to `ippBorderInMem`, destination image pixels mapped to the outer source image pixels are not changed. The outer pixels are obtained from the out of of the source image origin space, if they are required by interpolation algorithm.
   - The mixed border types can be obtained by the bitwise operation OR between `ippBorderTransp` and the `ippBorderInMemTop`, `ippBorderInMemBottom`, `ippBorderInMemLeft`, `ippBorderInMemRight` values.

Figure *Whole Image Warping* shows a simple image affine transformation example. Transformation coefficients are `{{1.0, 0.5, 0.0}, {0.5, 1.0, 0.0}}`, border type is `ippBorderConst`, `pBorderValue` is a white color pixel. The size of the destination image is 1.2x of the source image size.

**Whole Image Warping**

![a) source image](image1.png) ![b) image after transformation](image2.png)
The code example below demonstrates affine transformation of the whole image with the linear interpolation method:

```c
IppStatus warpAffineExample_8u_C3R(Ipp8u* pSrc, IppiSize srcSize, Ipp32s srcStep, Ipp8u* pDst, IppiSize dstSize,
    Ipp32s dstStep, const double coeffs[2][3])
    {
        IppiWarpSpec* pSpec = 0;
        int specSize = 0, initSize = 0, bufSize = 0; Ipp8u* pBuffer = 0;
        const Ipp32u numChannels = 3;
        IppiPoint dstOffset = {0, 0};
        IppStatus status = ippStsNoErr;
        IppiBorderType borderType = ippBorderConst;
        IppiWarpDirection direction = ippWarpForward;
        Ipp64f pBorderValue[numChannels];

        for (int i = 0; i < numChannels; ++i) pBorderValue[i] = 255.0;

        /* Spec and init buffer sizes */
        status =ippiWarpAffineGetSize(srcSize, dstSize, ipp8u, coeffs, ippLinear, direction, borderType, &specSize, &initSize);
        if (status != ippStsNoErr) return status;

        /* Memory allocation */
        pSpec = (IppiWarpSpec*)ippsMalloc_8u(specSize);
        if (pSpec == NULL)
            { return ippStsNoMemErr; }

        /* Filter initialization */
        status = ippiWarpAffineLinearInit(srcSize, dstSize, ipp8u, coeffs, direction, numChannels,
                                           borderType, pBorderValue, 0, pSpec);
        if (status != ippStsNoErr)
            {
                ippsFree(pSpec);
                return status;
            }

        /* work buffer size */
        status =ippiWarpGetBufferSize(pSpec, dstSize, &bufSize);
        if (status != ippStsNoErr)
            { 
                ippsFree(pSpec);
                return status;
            }

        pBuffer = ippsMalloc_8u(bufSize);
        if (pBuffer == NULL)
            { 
                ippsFree(pSpec);
                return ippStsNoMemErr;
            }
    }
```
/* Resize processing */
    status =ippiWarpAffineLinear_8u_C3R(pSrc, srcStep, pDst, dstStep, dstOffset, dstSize, pSpec, pBuffer);
    ippsFree(pSpec);
    ippsFree(pBuffer);
    return status;
}

Warping a Tiled Image with One Prior Initialization

You can follow the approach described below to apply affine transformation when the source image is fully accessible in memory and destination image is not fully accessible in memory, or to improve performance of warping by external threading.

The main difference between this approach and whole image warping is that the image is split into sections called tiles. Each call of the WarpAffine<Filter> function works with the destination image origin region of interest (ROI) that is defined by dstRoiOffset and dstRoiSize parameters. The destination ROI must be fully accessible in memory.

To resize an image with the tiled approach:

1. Call the WarpAffineGetSize function with the appropriate interpolation type. This function uses the size of the source and destination images and transformation parameters to calculate how much memory must be allocated for the IppWarpSpec structure and initialization work buffer.
2. Initialize the IppWarpSpec structure by callingippiWarpAffine<Filter>Init, where <Filter> can take one of the following values: Nearest, Linear, and Cubic.
3. Determine an appropriate partitioning scheme to divide the destination image into tiles. Tiles can be sets of rows or a regular grid of subimages. A simple vertical subdivision into sets of lines is sufficient in most cases.
4. Call the WarpBufferSize function to obtain the size of the work buffer required for each tile processing. The dstRoiSize parameter must be equal to the tile size.
5. CallippiWarpAffine<Filter> for each tile (ROI). The dstRoiOffset parameter must specify the image ROI offset with respect to the destination image origin. The dstRoiSize parameter must be equal to the ROI size. The pDst parameter must point to the beginning of the destination ROI in memory. The source and destination ROIs must be fully accessible in memory.

You can process tiles in any order. When using multiple threads you can process all tiles simultaneously.
Figure *Tiled Image Warping* shows the affine transformation of the image divided into tiles. Transformation coefficients are \([\{1.0, 0.5, 0.0\}, \{0.5, 1.0, 0.0\}]\), applied border type is `ippBorderConst`, `pBorderValue` is a white color pixel. The size of the destination image is 1.2x of the source image size.

### Tiled Image Warping

![Image of tiled image warping](image)

**Example**

The code example below demonstrates a multithreading affine transformation using OpenMP* with parallelization only in y direction:

```c
IppStatus tileWarpAffineExample_C3R(Ipp8u* pSrc, IppiSize srcSize, Ipp32s srcStep, Ipp8u* pDst, IppiSize dstSize, Ipp32s dstStep, const double coeffs[2][3])
{
    IppiWarpSpec* pSpec = 0;
    int specSize = 0, initSize = 0, bufSize = 0; Ipp8u* pBuffer = 0;
    Ipp8u* pInitBuf = 0;
    const Ipp32u numChannels = 3;
    IppPoint dstOffset = {0, 0};
    IppPoint srcOffset = {0, 0};
    IppStatus status = ippStsNoErr;
    IppiBorderType borderType = ippBorderConst;
    IppiWarpDirection direction = ippWarpForward;
    int numThreads, slice, tail;
    int bufSize1, bufSize2;
    IppiSize dstTileSize, dstLastTileSize; IppStatus pStatus[MAX_NUM_THREADS];
    Ipp64f pBorderValue[numChannels];

    for (int i = 0; i < numChannels; ++i) pBorderValue[i] = 255.0;

    /* Spec and init buffer sizes */
    status = ippiWarpAffineGetSize(srcSize, dstSize, ipp8u, coeffs, ippLinear, direction, borderType, &specSize, &initSize);
    if (status != ippStsNoErr) return status;

    /* Memory allocation */
    pSpec = (IppiWarpSpec*)ippsMalloc_8u(specSize);
    if (pSpec == NULL)
    {
        return ippStsNoMemErr;
    }
```
/* Filter initialization */
status = ippiWarpAffineLinearInit(srcSize, dstSize, ipp8u, coeffs, direction, numChannels,
borderType, pBorderValue, 0, pSpec);

if (status != ippStsNoErr)
{
  ippsFree(pSpec);
  return status;
}

/* General transform function */
/* Parallelized only by Y-direction here */
#pragma omp parallel num_threads(MAX_NUM_THREADS)
{
  #pragma omp master
  {
    numThreads = omp_get_num_threads();

    slice = dstSize.height / numThreads; tail = dstSize.height % numThreads;

    dstTileSize.width = dstLastTileSize.width = dstSize.width;
    dstTileSize.height = slice;
    dstLastTileSize.height = slice + tail;

    ippiWarpGetBufferSize(pSpec, dstTileSize, &bufSize1);
    ippiWarpGetBufferSize(pSpec, dstLastTileSize, &bufSize2);

    pBuffer = ippsMalloc_8u(bufSize1 * (numThreads - 1) + bufSize2);
  }

  #pragma omp barrier
  {
    if (pBuffer)
    {
      Ipp32u i;
      Ipp8u *pDstT; Ipp8u *pOneBuf;
      IppiPoint srcOffset = {0, 0};
      IppiPoint dstOffset = {0, 0};
      IppiSize srcSizeT = srcSize; IppiSize dstSizeT = dstTileSize;

      i = omp_get_thread_num();

      dstSizeT.height = slice; dstOffset.y += i * slice;
      if (i == numThreads - 1) dstSizeT = dstLastTileSize;
      pDstT = (Ipp8u*)((char*)pDst + dstOffset.y * dstStep);
      pOneBuf = pBuffer + i * bufSize1;

      pStatus[i] = ippiWarpAffineLinear_8u_C3R (pSrc, srcStep, pDstT, dstStep,
      dstOffset, dstSizeT, pSpec, pOneBuf);
    }
  }
}
See Also

User-defined Border Types

**WarpAffineGetSize** Computes the size of the specification structure and the size of the external work buffer for the warp affine transform.

**WarpGetBufferSize** Computes the size of the work buffer for the warp transform.

Edge Smoothing

The *Smooth Edge* feature is an artificial method to reduce aliasing artifacts at the transformed source image edges. Aliasing artifacts may appear because the transformation algorithms skip a destination pixel if its source origin is out of the source image ROI. Thus, borders of the transformed source image can look stepped:

If the *smoothEdge* flag is set, destination pixels that are closest to the transformed source image edges are mixed with sampled source pixels by the following formula:

\[ \text{dstRes} = \text{srcSampled} \times (1 - a) + \text{dstExist} \times a \]

where

- *srcSampled* is the intensity of the source pixel after transformation.
- *dstExist* is the intensity of the destination pixel before transformation.
- *a* is the weight of the outer pixel; set by the function.
- *dstRes* is the intensity of the resulting destination pixel.
The edge smoothing method is not universal: in some cases it can improve the image, but in other cases it can be inefficient. For example, edge smoothing does not increase the quality of images with high contrast borders, and it is not recommended to apply edge smoothing to such images.

**NOTE**

Edge smoothing is a post-processing operation: it is performed after transformation. When warping a tiled image, artifacts may appear on tile borders. In this case, edges are not smoothed.

**GetAffineQuad**

*Computes vertex coordinates of the quadrangle, to which the source ROI rectangle is mapped by the affine transform.*

**Syntax**

IppStatus ippiGetAffineQuad (IppiRect srcRoi, double quad[4][2], const double coeffs[2][3]);

IppStatus ippiGetAffineQuad_L(IppiRectL srcRoi, double quad[4][2], const double coeffs[2][3]);

**Include Files**

ippi.h

Flavors with the _L suffix: ippi_l.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

*srcRoi*  
Region of interest in the source image (of the IppiRect type).

*quad*  
Output array. Contains vertex coordinates of the quadrangle, to which the source ROI is mapped by the affine transform function.

*coeffs*  
The given affine transform coefficients.

**Description**

This function operates with ROI (see ROI Processing in Geometric Transforms).

This function is used as a support function for WarpAffineNearest, WarpAffineLinear, and WarpAffineCubic functions. It computes vertex coordinates of the quadrangle, to which the source rectangular ROI is mapped by the affine transform function using the given coefficients *coeffs*.

The first dimension [4] of the array *quad*[4][2] is equal to the number of vertices, and the second dimension [2] means x and y coordinates of the vertex. Quadrangle vertices have the following meaning:

*quad*[0] corresponds to the transformed top-left corner of the source ROI,

*quad*[1] corresponds to the transformed top-right corner of the source ROI,

*quad*[2] corresponds to the transformed bottom-right corner of the source ROI,

*quad*[3] corresponds to the transformed bottom-left corner of the source ROI.
Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error.

ippStsCoeffErr
Indicates an error condition if \( c_{00}c_{11} - c_{01}c_{10} = 0 \).

ippStsSizeErr
Indicates an error condition if \( srcRoi \) has a size field with zero or negative value.

GetAffineBound

*Computes the bounding rectangle for the source ROI transformed by the ippiWarpAffine function.*

Syntax

```c
IppStatus ippiGetAffineBound (IppiRect srcRoi, double bound[2][2], const double coeffs[2][3]);
```

Platform-aware functions

```c
IppStatus ippiGetAffineBound_L (IppiRectL srcRoi, double bound[2][2], const double coeffs[2][3]);
```

Include Files

ippi.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **srcRoi**
  Region of interest in the source image (of the IppiRect type).

- **bound**
  Output array. Contains vertex coordinates of the bounding rectangle for the transformed source ROI.

- **coeffs**
  The given affine transform coefficients.

Description

This function is used as a support function for WarpAffineNearest, WarpAffineLinear, and WarpAffineCubic functions. It computes vertex coordinates of the smallest bounding rectangle for the quadrangle \( quad \), to which the source ROI is mapped by the affine transform function using coefficients \( coeffs \).

- \( bound[0] \) specifies \( x, y \) coordinates of the top-left corner, \( bound[1] \) specifies \( x, y \) coordinates of the bottom-right corner.

Return Values

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.

- **ippStsCoeffErr**
  Indicates an error condition if \( c_{00}c_{11} - c_{01}c_{10} = 0 \).

- **ippStsSizeErr**
  Indicates an error condition if \( srcRoi \) has a size field with zero or negative value.
GetAffineSrcRoi
*Computes ROI of an image for affine transform.*

**Syntax**

```
IppStatus ippiGetAffineSrcRoi (IppiSize srcSize, const double coeffs[2][3],
IppiWarpDirection direction, IppiPoint dstRoiOffset, IppiSize dstRoiSize, IppiRect *srcRoi);
```

**Platform-aware functions**

```
IppStatus ippiGetAffineSrcRoi_L (IppiSizeL srcSize, const double coeffs[2][3],
IppiWarpDirection direction, IppiPointL dstRoiOffset, IppiSizeL dstRoiSize, IppiRectL* srcRoi);
```

**Include Files**

ipi.h

Flavors with the _L suffix: ippi_l.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **srcSize**
  Size of the source image, in pixels.

- **coeffs**
  Coefficients for affine transform.

- **direction**
  Transformation direction. Supported values:
  - ippWarpForward
  - ippWarpBackward

- **dstRoiSize**
  Size of the ROI of destination image.

- **dstRoiOffset**
  Offset of the destination image ROI.

- **srcRoi**
  Pointer to the computed region of interest in the source image.

**Description**

This function operates with ROI (see ROI Processing in Geometric Transforms).

This function is used as a support function for the ippiWarpAffineLinear, WarpAffineNearest, and WarpAffineCubic functions. It computes ROI of the source image to perform affine transformation for a given destination ROI. To process the given destination ROI, the computed source ROI with borders must be accessible in memory. If the source ROI outside pixels are out of the source image origin, the border pixels are processed according to the border flag that is passed to the ippiWarpAffineLinear, WarpAffineNearest, and WarpAffineCubic functions.

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or warning.

- **ippStsRectErr**
  Indicates an error condition if width or height of the srcRoi is less than or equal to 1.
ippStsOutOfRangeErr
Indicates an error if the destination image offset has a field with a negative value.

ippStsSizeErr
Indicates an error condition if width or height of the source or destination image is less than, or equal to zero.

ippStsWrongIntersetQuad
Indicates a warning that no operation is performed because the transformed source image has no intersection with the destination ROI.

ippStsNullPtrErr
Indicates an error if one of the specified pointers is NULL.

ippStsWarpDirectionErr
Indicates an error when the direction value is illegal.

ippStsCoefErr
Indicates an error condition, if affine transformation is singular.

GetAffineTransform
Computes affine transform coefficients to map the source ROI to the quadrangle with the specified vertex coordinates

Syntax
IppStatus ippiGetAffineTransform (IppiRect srcRoi, const double quad[4][2], double coeffs[2][3]);

Platform-aware functions
IppStatus ippiGetAffineTransform_L (IppiRectL srcRoi, const double quad[4][2], double coeffs[2][3]);

Include Files
ippi.h

Flavors with the _L suffix:ippi_l.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
srcRoi
Region of interest in the source image (of the IppiRect type).

quad
Vertex coordinates of the quadrangle, to which the source ROI is mapped by the affine transform function.

coeffs
Output array. Contains the target affine transform coefficients.

Description
This function operates with ROI (see ROI Processing in Geometric Transforms).

This function is used as a support function for the ippiWarpAffineLinear, WarpAffineNearest, and WarpAffineCubic functions. It computes the coefficients coeffs of the affine transform that must be used by the warping function to map the source rectangular ROI to the quadrangle with the specified vertex coordinates quad. The first dimension [4] of the array quad[4][2] is equal to the number of vertices, and the second dimension [2] means x and y coordinates of the vertex. Quadrangle vertices have the following meaning:
quad[0] corresponds to the transformed top-left corner of the source ROI, quad[1] corresponds to the transformed top-right corner of the source ROI, quad[2] corresponds to the transformed bottom-right corner of the source ROI, quad[3] corresponds to the transformed bottom-left corner of the source ROI.

The function computes the coordinates of the 4th vertex of the destination quadrangle that uniquely depends on the three other vertices. If the computed coordinates are not equal to the ones specified in quad, the function returns the warning message and continues operation with the computed values.

**Return Values**

**ippStsNoErr**
Indicates no error. Any other value indicates an error or warning.

**ippStsRectErr**
Indicates an error condition if width or height of the srcRoi is less than or equal to 1.

**ippStsCoeffErr**
Indicates an error condition if \( c_{00} \cdot c_{11} - c_{01} \cdot c_{10} = 0 \).

**ippStsSizeErr**
Indicates an error condition if srcRoi has a size field with zero or negative value.

**ippStsAffineQuadChanged**
Indicates a warning that coordinates of the 4th vertex of the specified quadrangle quad are not correct.

**GetRotateTransform**
Computes the affine coefficients for the rotation transform.

**Syntax**

```c
IppStatus ippiGetRotateTransform(double angle, double xShift, double yShift, double coeffs[2][3]);
```

**Platform-aware functions**

```c
IppStatus ippiGetRotateTransform_L(double angle, double xShift, double yShift, double coeffs[2][3]);
```

**Include Files**

ippi.h

Flavors with the _L suffix:ippi_l.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **angle**
  Angle of rotation, in degrees. The source image is rotated counterclockwise around the origin (0, 0).

- **xShift, yShift**
  Shift along horizontal (x) or vertical (y) axis that is performed after rotation.

- **coeffs**
  Computed affine transform coefficients for the given rotation parameters.
Description
This function computes the coefficients for the affine transform that rotates an image by the specified angle around the origin (0, 0) and shifts the image after rotation. The result is stored in the `coeffs` parameter.

Return Values
- `ippStsNoErr`: Indicates no error. Any other value indicates an error.
- `ippStsSizeErr`: Indicates an error when one of the `coeffs` values is `NULL`.
- `ippStsOutOfRangeErr`: Indicates an error when `angle` is not-a-number (NaN) or infinity.

Example
To better understand usage of the `ippiGetRotateTransform` function, refer to the `GetRotateTransform.c` example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

GetRotateShift
*Computes shift values for rotation of an image around the specified center.*

Syntax
```c
IppStatus ippiGetRotateShift (double xCenter, double yCenter, double angle, double* xShift, double* yShift);
```

Platform-aware functions
```c
IppStatus ippiGetRotateShift_L (double xCenter, double yCenter, double angle, double* xShift, double* yShift);
```

Include Files
`ippi.h`

Flavors with the `_L` suffix: `ippi_l.h`

Domain Dependencies
Headers: `ippcore.h`, `ippvm.h`, `ipps.h`

Libraries: `ippcore.lib`, `ippvm.lib`, `ipps.lib`

Parameters
- `xCenter, yCenter`: Coordinates of the required center of rotation.
- `angle`: The angle in degrees to rotate the image clockwise around the point with coordinates `(xCenter, yCenter)`.
- `xShift, yShift`: Pointers to computed shift values along horizontal and vertical axes. These shift values should be passed to `ippiRotate` function to bring about the desired rotation around `(xCenter, yCenter)`.

Description
Use this function if you need to rotate an image about an arbitrary center `(xCenter, yCenter)` rather than the origin (0,0). The function helps compute shift values `xShift, yShift` that should be passed to the warping function for the rotation around `(xCenter, yCenter)` to take place.
Example shows how to use the function `ippiGetRotateShift`.

**Return Values**

- `ippStsNoErr`: Indicates no error. Any other value indicates an error.
- `ippStsNullPtrErr`: Indicates an error condition if `xShift` or `yShift` pointer is `NULL`.

**WarpAffineGetSize**

*Computes the size of the specification structure and the size of the external work buffer for the warp affine transform.*

**Syntax**

```c
IppStatus ippiWarpAffineGetSize(IppiSize srcSize, IppiSize dstSize, IppDataType dataType, const double coeffs[2][3], IppInterpolationType interpolation, IppiWarpDirection direction, IppiBorderType borderType, int* pSpecSize, int* pInitBufSize);
```

**Platform-aware functions**

```c
IppStatus ippiWarpAffineGetSize_L(IppiSizeL srcSize, IppiSizeL dstSize, IppDataType dataType, const double coeffs[2][3], IppInterpolationType interpolation, IppiWarpDirection direction, IppiBorderType borderType, int flags, IppSizeL* pSpecSize, IppSizeL* pInitBufSize);
```

**Include Files**

- `ippi.h`
- Flavors with the `_L` suffix: `ippi_l.h`

**Domain Dependencies**

- **Headers:** `ippcore.h`, `ippvm.h`, `ipps.h`
- **Libraries:** `ippcore.lib`, `ippvm.lib`, `ipps.lib`

**Parameters**

- **srcSize**: Size of the source image, in pixels.
- **dstSize**: Size of the destination image, in pixels.
- **dataType**: Data type of the source and destination images. Supported values: `ipp8u`, `ipp16u`, `ipp16s`, `ipp32f`, and `ipp64f`.
- **coeffs**: Coefficients for the affine transform.
- **interpolation**: Interpolation method. Supported values: `ippNearest`, `ippLinear`, and `ippCubic`.
- **direction**: Transformation direction. Supported values: `ippWarpForward` (forward transformation) and `ippWarpBackward` (backward transformation).
- **borderType**: Type of border. Possible values are:
Values of all border pixels are set to constant.

Border is replicated from the edge pixels.

Outer pixels are not processed.

Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderTransp and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.

Warp algorithm flags. Supported values:

- 0 - transformation without edge smoothing.
- 1 - transformation with edge smoothing. The feature is supported for the ippBorderTransp and ippBorderInMem border types.

Pointer to the size, in bytes, of the specification structure.

Pointer to the size, in bytes, of the temporary buffer.

This function computes the size of the specification structure and the external work buffer for the following functions, depending on the interpolation parameter: WarpAffineNearestInit, WarpAffineLinearInit, or WarpAffineCubicInit.

Indicates no error.

Indicates an error when one of the specified pointers is NULL.

Indicates a warning if width or height of any image is zero.

Indicates an error if the width or height of the source or destination image is less than, or equal to one.

Indicates an error when dataType has an illegal value.

Indicates an error when direction has an illegal value.

Indicates an error when interpolation has an illegal value.

Indicates an error if the requested mode is not supported.

Indicates an error when affine transformation is singular.

Indicates an error when borderType has an illegal value.

Indicates a warning that no operation is performed if the transformed source image extended with borders has no intersection with the destination image.
Indicates an error in the following cases:

- If one of the calculated sizes exceeds maximum of the pSpecSize variable data type positive value (the size of one of the processed images is too large).
- If width or height of the destination image or the source image exceeds 33554431 (0xFFFFFFF).

**See Also**

WarpAffineNearestInit  Initializes the specification structure for image affine warping with the nearest neighbor interpolation method.

WarpAffineLinearInit  Initializes the specification structure for image affine warping with the linear interpolation method.

WarpAffineCubicInit  Initializes the specification structure for image affine warping with the cubic interpolation method.

**WarpQuadGetSize**

*Computes the size of the specification structure and the size of the temporary buffer for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image.*

**Syntax**

```c
IppStatus ippiWarpQuadGetSize(IppiSize srcSize, const double srcQuad[4][2], IppiSize dstSize, const double dstQuad[4][2], IppiWarpTransformType transform, IppDataType dataType, IppiInterpolationType interpolation, IppiBorderType borderType, int* pSpecSize, int* pInitBufSize);
```

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **srcSize**
  Size of the source image, in pixels.

- **srcQuad**
  Quadrangle in the source image.

- **dstSize**
  Size of the destination image, in pixels.

- **dstQuad**
  Quadrangle in the destination image.

- **transform**
  Type of the warp transform. Supported values:
  - ippWarpAffine  Affine warping
  - ippWarpPerspective  Perspective warping

- **dataType**
  Data type of the source and destination images. Supported values: ipp8u, ipp16u, ipp16s, and ipp32f.

- **interpolation**
  Interpolation method. Supported values: ippNearest, ippLinear, and ippCubic.
borderType

Type of border. Supported values:

- ippBorderTransp (Outer pixels are not processed).
- ippBorderInMem (Border is obtained from the source image pixels in memory).

pSpecSize

Pointer to the size, in bytes, of the specification structure.

pInitBufSize

Pointer to the size, in bytes, of the temporary buffer.

Description

This function computes the size of the specification structure and the temporary buffer for the following functions, depending on the interpolation parameter: ippiWarpQuadNearestInit, ippiWarpQuadLinearInit, or ippiWarpQuadCubicInit.

Return Values

- ippStsNoErr (Indicates no error).
- ippStsNullPtrErr (Indicates an error when one of the specified pointers is NULL).
- ippStsSizeErr (Indicates an error in the following cases:
  - If the width or height of the source or destination image is less than, or equal to one.
  - If one of the calculated sizes exceeds the maximum positive 32-bit signed integer value. The size of the one of the processed images is too large.
- ippStsDataTypeErr (Indicates an error when dataType has an illegal value).
- ippStsWarpTransformErr (Indicates an error when transform has an illegal value).
- ippStsInterpolationErr (Indicates an error when interpolation has an illegal value).
- ippStsQuadErr (Indicates an error when any of the given quadrangles is non-convex or degenerates into a triangle, line, or point).
- ippStsWrongIntersectQuad (Indicates a warning that no operation is performed if the transformed source image extended with borders has no intersection with the destination image).
- ippStsAffineQuadChanged (Indicates a warning when coordinates of the fourth vertex of dstQuad are changed by the function, if transform is set to ippWarpAffine).
- ippStsBorderErr (Indicates an error when borderType has an illegal value).

See Also

- WarpQuadNearestInit: Initializes the specification structure for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image with the nearest neighbor interpolation method.
- WarpQuadLinearInit: Initializes the specification structure for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image with the linear interpolation method.
- WarpQuadCubicInit: Initializes the specification structure for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image with the cubic interpolation method.
WarpGetBufferSize

Computes the size of the work buffer for the warp transform.

Syntax

IppStatus ippiWarpGetBufferSize(const IppiWarpSpec* pSpec, IppiSize dstRoiSize, int* pBufSize);

Platform-aware functions

IppStatus ippiWarpGetBufferSize_L(const IppiWarpSpec* pSpec, IppSizeL dstRoiSize, IppSizeL* pBufSize);

Include Files

ippi.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSpec

Pointer to the specification structure for the warp operation.

dstRoiSize

Size of the processed destination image ROI, in pixels.

pBufSize

Pointer to the size of the external buffer, in bytes.

Description

This function computes the size of the external buffer for the warp transform. The specification structure pointed by pSpec defines the warp algorithm parameters.

Before using this function, you need to initialize the specification structure using one of the following functions: WarpAffineNearestInit, WarpAffineLinearInit, or WarpAffineCubicInit.

Return Values

ippStsNoErr

Indicates no error.

ippStsNullPtrErr

Indicates an error when one of the specified pointers is NULL.

ippStsContextMatchErr

Indicates an error when the specification structure is invalid.

ippStsSizeErr

Indicates an error in the following cases:

- If width or height of the destination image is negative, or equal to zero.
- If the calculated buffer size exceeds the maximum positive pBufSize data type. The size of the processed image ROI is too large.

ippStsSizeWrn

Indicates a warning when the size of the destination image is more than the size of the destination image origin.
See Also

WarpAffineNearestInit Initializes the specification structure for image affine warping with the nearest neighbor interpolation method.

WarpAffineLinearInit Initializes the specification structure for image affine warping with the linear interpolation method.

WarpAffineCubicInit Initializes the specification structure for image affine warping with the cubic interpolation method.

WarpAffineNearestInit
Initializes the specification structure for image affine warping with the nearest neighbor interpolation method.

Syntax

IppStatus ippiWarpAffineNearestInit(IppiSize srcSize, IppiSize dstSize, IppDataType dataType, const double coeffs[2][3], IppiWarpDirection direction, int numChannels, IppiBorderType borderType, const Ipp64f* pBorderValue, int smoothEdge, IppiWarpSpec* pSpec);

Platform-aware functions

IppStatus ippiWarpAffineNearestInit_L(IppiSizeL srcSize, IppiSizeL dstSize, IppDataType dataType, const double coeffs[2][3], IppiWarpDirection direction, int numChannels, IppiBorderType borderType, const Ipp64f* pBorderValue, int flags, IppiWarpSpec* pSpec);

Include Files

ippi.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

srcSize
Size of the source image, in pixels.

dstSize
Size of the destination image, in pixels.

dataType
Data type of the source and destination images. Supported values: ipp8u, ipp16u, ipp16s, ipp32f, and ipp64f.

coeffs
Coefficients for the affine transform.

direction
Transformation direction. Supported values:

ippWarpForward Forward transformation
ippWarpBackward Backward transformation

numChannels
Number of channels in the image. Supported values: 1, 3, or 4.

borderType
Type of border. Supported values:
Values of all border pixels are set to a constant.

Border is replicated from the edge pixels.

Outer pixels are not processed.

Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderTransp and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.

Warp algorithm flags. Supported values:
- 0 - transformation without edge smoothing.
- 1 - transformation with edge smoothing. The feature is supported for the ippBorderTransp and ippBorderInMem border types.

Pointer to the constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

Flag for edge smoothing. Supported values:
- 0 - transformation without edge smoothing.
- 1 - transformation with edge smoothing. This feature is supported only for the ippBorderTransp and ippBorderInMem border types.

Pointer to the specification structure.

This function initializes the IppiWarSpec structure for theippiWarpAffineNearest function that performs warp affine transformation with the nearest neighbor interpolation method. To compute the size of the specification structure, use the WarpAffineGetSize function.

Indicates no error.

Indicates an error when:
- one of the specified pointers is NULL, excepting pBorderValue
- pBorderValue is NULL when border type is set to ippBorderConst

Indicates a warning if width or height of any image is zero.

Indicates an error when width or height of the source or destination image is less than, or equal to one.
Image Geometry Transforms

ippStsDataTypeErr

Indicates an error when `dataType` has an illegal value.

ippStsWarpDirectionErr

Indicates an error when `direction` has an illegal value.

ippStsCoeffErr

Indicates an error when affine transformation is singular.

ippStsWrongIntersectQuad

Indicates a warning that no operation is performed if the transformed source image extended with borders has no intersection with the destination image. The edge smoothing feature is not supported for the ippBorderRepl and ippBorderConst border types.

ippStsNotSupportedModeErr

Indicates an error when the requested mode is not supported.

ippStsBorderErr

Indicates an error when `borderType` has an illegal value.

ippStsNumChannelsErr

Indicates an error when `numChannels` has an illegal value.

ippStsExceededSizeErr

Indicates an error if width or height of the destination image or the source image exceeds 33554431 (0x1FFFFFF).

See Also

WarpAffineGetSize Computes the size of the specification structure and the size of the external work buffer for the warp affine transform.

WarpQuadNearestInit

Initializes the specification structure for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image with the nearest neighbor interpolation method.

Syntax

```c
IppStatus ippiWarpQuadNearestInit(IppiSize srcSize, const double srcQuad[4][2], IppiSize dstSize, const double dstQuad[4][2], IppiWarpTransformType transform, IppDataType dataType, int numChannels, IppiBorderType borderType, const Ipp64f* pBorderValue, int smoothEdge, IppiWarpSpec* pSpec);
```

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- `srcSize` Size of the source image, in pixels.
- `srcQuad` Quadrangle in the source image.
- `dstSize` Size of the destination image, in pixels.
- `dstQuad` Quadrangle in the destination image.
- `transform` Type of the warp tranform. Supported values:
  - ippWarpAffine Affine warping
ippWarpPerspective Perspective warping

dataType
Data type of the source and destination images. Supported values: ipp8u, ipp16u, ipp16s, and ipp32f.

numChannels
Number of channels in the image. Supported values: 1, 3, or 4.

borderType
Type of border. Supported values:
- ippBorderTransp Outer pixels are not processed.
- ippBorderInMem Border is obtained from the source image pixels in memory.

pBorderValue
Pointer to the constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

smoothEdge
Flag for edge smoothing. Supported values:
- 0 - transformation without edge smoothing.
- 1 - transformation with edge smoothing.

pSpec
Pointer to the specification structure.

Description
This function initializes the IppiWarpSpec structure for warping an arbitrary quadrangle in the source image to quadrangle in the destination image with the nearest neighbor interpolation method. To compute the size of the specification structure, use the WarpQuadGetSize function.

Transformation coefficients are computed internally, based on the mapping of the source quadrangle to the specified destination quadrangle dstQuad and transform type transform. In case of affine transform, the function computes the coordinates of the fourth vertex of the destination quadrangle that uniquely depends on the three other vertices. If the computed coordinates are not equal to the corresponding values specified in dstQuad, the function returns the warning message and continues initialization with the computed values.


You can apply the edge smoothing feature only if the source quadrangle entirely lies in the source image.

Return Values

ippStsNoErr Indicates no error.

ippStsNullPtrErr Indicates an error when:
- One of the specified pointers is NULL, excepting pBorderValue
- The value of pBorderValue is NULL when the border type is set to ippBorderConst

ippStsSizeErr Indicates an error when width or height of the source or destination image is less than, or equal to one.

ippStsDataTypeErr Indicates an error when dataType has an illegal value.

ippStsWarpTransformErr Indicates an error when transform has an illegal value.

ippStsQuadErr Indicates an error when any of the given quadrangles is non-convex or degenerates into a triangle, line, or point.
Indicates a warning that no operation is performed if the transformed source image extended with borders has no intersection with the destination image.

Indicates a warning when coordinates of the fourth vertex of dstQuad are changed by the function, if transform is set to ippWarpAffine.

Indicates an error when borderType has an illegal value.

Indicates an error when numChannels has an illegal value.

Example
To better understand usage of the ippiWarpQuadNearest, ippiWarpQuadLinear, and ippiWarpQuadCubic functions, refer to the WarpQuadNearestInit.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

See Also
WarpQuadGetSize Computes the size of the specification structure and the size of the temporary buffer for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image.

WarpAffineNearest
Performs warp affine transformation of an image using the nearest neighbor interpolation method.

Syntax
IPP_STATUS ippiWarpAffineNearest_<mod>(const IPPI_DATATYPE* pSrc, int srcStep, IPPI_DATATYPE* pDst, int dstStep, IPPI_POINT dstRoiOffset, IPPI_SIZE dstRoiSize, const IPPI_WARP_SPEC* pSpec, Ipp8u* pBuffer);

Supported values for mod:

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32f_C1R
- 64f_C1R

- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32f_C3R
- 64f_C3R

- 8u_C4R
- 16u_C4R
- 16s_C4R
- 32f_C4R
- 64f_C4R

Platform-aware functions
IPP_STATUS ippiWarpAffineNearest_<mod>(const IPPI_DATATYPE* pSrc, IPP_SIZE srcStep, IPPI_DATATYPE* pDst, IPP_SIZE dstStep, IPPI_POINT dstRoiOffset, IPP_SIZE dstRoiSize, const IPPI_WARP_SPEC* pSpec, Ipp8u* pBuffer);

Supported values for mod:

- 8u_C1R_L
- 16u_C1R_L
- 16s_C1R_L
- 32f_C1R_L
- 64f_C1R_L

- 8u_C3R_L
- 16u_C3R_L
- 16s_C3R_L
- 32f_C3R_L
- 64f_C3R_L

- 8u_C4R_L
- 16u_C4R_L
- 16s_C4R_L
- 32f_C4R_L
- 64f_C4R_L

Include Files
ippi.h
Flavors with the _L suffix: ippi_l.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- **pSrc**
  Pointer to the source image.
- **srcStep**
  Distance, in bytes, between the starting points of consecutive lines in the source image buffer.
- **pDst**
  Pointer to the destination image ROI.
- **dstStep**
  Distance, in bytes, between the starting points of consecutive lines in the destination image buffer.
- **dstRoiOffset**
  Offset of the destination image ROI with respect to the destination image origin.
- **dstRoiSize**
  Size of the destination image ROI, in pixels.
- **pSpec**
  Pointer to the specification structure for the warp operation.
- **pBuffer**
  Pointer to the work buffer.

Description

This function transforms the source image pixel coordinates \((x, y)\) according to the following formulas:

\[
\begin{align*}
x' &= c_{00}x + c_{01}y + c_{02} \\
y' &= c_{10}x + c_{11}y + c_{12}
\end{align*}
\]

where

- \(x'\) and \(y'\) are the pixel coordinates in the transformed image
- \(c_{ij}\) are the affine transform coefficients passed to the `coeffs` array during initialization

The affine warping is a general linear transform that incorporates such elementary transformations as scaling, rotation, translation, stretching, and shearing. It always transforms parallel lines into parallel lines and preserves equal distances between points on a line.

The `WarpAffineNearest` function operates with ROI. The transformed part of the image is resampled with the nearest neighbor interpolation method and stored in the destination image ROI. You need to define the destination image ROI origin by the following parameters: the offset of the destination ROI with respect to the destination image origin and the destination image ROI size. The parameter `pSrc` must point to the source image origin. The parameter `pDst` must point to the processed destination image ROI.

If you initialize the specification structure using the `WarpQuadNearestInit` function, the operations take place only inside the specified source quadrangle `srcQuad` that is set in `WarpQuadNearestInit`.

To specify the algorithm for borders processing, set the `borderType` and `pBorderValue` parameters when initializing the `IppiWarpSpec` structure. The data type of `pBorderValue` is automatically converted from `Ipp64f` to the data type of the processed images. The function supports the following algorithms for borders processing:

- If the border type is equal to `ippBorderRepl`, the source image outer pixels are replicated from the edge pixels.
- If the border type is equal to `ippBorderConst`, the outer pixels are set to the constant value specified in `pBorderValue`. 
- If the border type is equal to ippBorderTransp or ippBorderInMem, destination image pixels mapped to the outer source image pixels are not changed.

Before using the WarpAffineNearest function, you need to initialize the IpplWarpSpec structure using the WarpAffineNearestInit function and compute the size of the external buffer pBuffer using the WarpGetBufferSize function.

To compute the affine transform parameters, use the GetAffineQuad, GetAffineBound, and GetAffineTransform functions.

For an example on how to use this function, refer to the WarpQuadNearestInit function description.

**Return Values**

ippStsNoErr Indicates no error.

ippStsNullPtrErr Indicates an error when one of the specified pointers is NULL.

ippStsNoOperation Indicates a warning when width or height of the destination image is equal to zero.

ippStsBorderErr Indicates an error if border type has an illegal value.

ippStsContextMatchErr Indicates an error when context data is invalid.

ippStsNotSupportedModeErr Indicates an error when the requested mode is not supported.

ippStsSizeErr Indicates an error when width or height of the source or destination image ROI is negative.

ippStsStepErr Indicates an error when the step value is not a multiple of data type.

ippStsOutOfRangeErr Indicates an error when the destination image offset point is outside the destination image origin.

ippStsSizeWrn Indicates a warning when the destination image ROI size is more than the destination image origin size.

ippStsWrongIntersectQuad Indicates a warning that no operation is performed if the destination ROI has no intersection with the transformed source image origin.

**See Also**

ROP  Processing in Geometric Transforms

WarpAffineNearestInit Initializes the specification structure for image affine warping with the nearest neighbor interpolation method.

WarpQuadNearestInit Initializes the specification structure for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image with the nearest neighbor interpolation method.

WarpGetBufferSize Computes the size of the work buffer for the warp transform.

GetAffineBound Computes the bounding rectangle for the source ROI transformed by the ippiWarpAffine function.

GetAffineQuad Computes vertex coordinates of the quadrangle, to which the source ROI rectangle is mapped by the affine transform.

GetAffineTransform Computes affine transform coefficients to map the source ROI to the quadrangle with the specified vertex coordinates.

WarpAffineLinearInit

*Initializes the specification structure for image affine warping with the linear interpolation method.*
Syntax

IppStatus ippiWarpAffineLinearInit(IppiSize srcSize, IppiSize dstSize, IppDataType dataType, const double coeffs[2][3], IppiWarpDirection direction, int numChannels, IppiBorderType borderType, const Ipp64f* pBorderValue, int smoothEdge, IppiWarpSpec* pSpec);

Platform-aware functions

IppStatus ippiWarpAffineLinearInit_L(IppiSizeL srcSize, IppiSizeL dstSize, IppDataType dataType, const double coeffs[2][3], IppiWarpDirection direction, int numChannels, IppiBorderType borderType, const Ipp64f* pBorderValue, int flags, IppiWarpSpec* pSpec);

Include Files

ippi.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

srcSize
Size of the source image, in pixels.

dstSize
Size of the destination image, in pixels.

dataType
Data type of the source and destination images. Supported values: ipp8u, ipp16u, ipp16s, ipp32f, and ipp64f.

coeffs
Coefficients for the affine transform.

direction
Transformation direction. Supported values:

ippWarpForward  Forward transformation
ippWarpBackward  Backward transformation

numChannels
Number of channels in the image. Supported values: 1, 3, or 4.

borderType
Type of border. Supported values:

ippBorderConst  Values of all border pixels are set to a constant.
ippBorderRepI  Border is replicated from the edge pixels.
ippBorderTransP  Outer pixels are not processed.
ippBorderInMem  Border is obtained from the source image pixels in memory.
Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderTransp and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.

flags

Warp algorithm flags. Supported values:
- 0 - transformation without edge smoothing.
- 1 - transformation with edge smoothing. The feature is supported for the ippBorderTransp and ippBorderInMem border types.

pBorderValue

Pointer to the constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

smoothEdge

Flag for edge smoothing. Supported values:
- 0 - transformation without edge smoothing.
- 1 - transformation with edge smoothing. This feature is supported only for the ippBorderTransp and ippBorderInMem border types.

pSpec

Pointer to the specification structure.

Description

This function initializes the IppiWarpSpec structure for theippiWarpAffineLinear function that performs warp affine transformation with the linear interpolation method. To compute the size of the specification structure, use the WarpAffineGetSize function.

Return Values

ippStsNoErr Indicates no error.
ippStsNullPtrErr Indicates an error when:
- one of the specified pointers is NULL, excepting pBorderValue
- pBorderValue is NULL when border type is set to ippBorderConst
ippStsNoOperation Indicates a warning if width or height of any image is zero.
ippStsSizeErr Indicates an error when width or height of the source or destination image is less than, or equal to one.
ippStsDataTypeErr Indicates an error when dataType has an illegal value.
ippStsWarpDirectionErr Indicates an error when direction has an illegal value.
ippStsCoeffErr Indicates an error when affine transformation is singular.
ippStsWrongIntersectQuad Indicates a warning that no operation is performed if the transformed source image extended with borders has no intersection with the destination image.
ippStsNotSupportedModeErr Indicates an error when the requested mode is not supported. The edge smoothing feature is not supported for the ippBorderRepl and ippBorderConst border types.
ippStsBorderErr
Indicates an error when borderType has an illegal value.

ippStsNumChannelsErr
Indicates an error when numChannels has an illegal value.

ippStsExceededSizeErr
Indicates an error if width or height of the destination image or
the source image exceeds 33554431 (0x1FFFFFF).

See Also
WarpAffineGetSize  Computes the size of the specification structure and the size of the external
work buffer for the warp affine transform.

WarpQuadLinearInit
Initializes the specification structure for warping an
arbitrary quadrangle in the source image to the
quadrangle in the destination image with the linear
interpolation method.

Syntax
IppStatus ippiWarpQuadLinearInit(IppiSize srcSize, const double srcQuad[4][2], IppiSize dstSize, const double dstQuad[4][2], IppWarpTransformType transform, IppDataType dataType, int numChannels, IppiBorderType borderType, const Ipp64f* pBorderValue, int smoothEdge, IppiWarpSpec* pSpec);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

srcSize
Size of the source image, in pixels.

srcQuad
Quadrangle in the source image.

dstSize
Size of the destination image, in pixels.

dstQuad
Quadrangle in the destination image.

transform
Type of the warp transform. Supported values:
ippWarpAffine  Affine warping
ippWarpPerspective  Perspective warping

dataType
Data type of the source and destination images. Supported
values: ipp8u, ipp16u, ipp16s, and ipp32f.

numChannels
Number of channels in the image. Supported values: 1, 3, or 4.

borderType
Type of border. Supported values:
ippBorderTransp  Outer pixels are not processed.
ippBorderInMem  Border is obtained from the source image pixels in memory.
pBorderValue  
Pointer to the constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

smoothEdge  
Flag for edge smoothing. Supported values:
- 0 - transformation without edge smoothing.
- 1 - transformation with edge smoothing.

pSpec  
Pointer to the specification structure.

Description
This function initializes the IppiWarpSpec structure for warping an arbitrary quadrangle in the source image to quadrangle in the destination image with the linear interpolation method. To compute the size of the specification structure, use the WarpQuadGetSize function.

Transformation coefficients are computed internally, based on the mapping of the source quadrangle to the specified destination quadrangle dstQuad and transform type transform. In case of affine transform, the function computes the coordinates of the fourth vertex of the destination quadrangle that uniquely depends on the three other vertices. If the computed coordinates are not equal to the corresponding values specified in dstQuad, the function returns the warning message and continues initialization with the computed values.


For an example on how to use this function, refer to the example provided with the WarpQuadNearestInit function description.

You can apply the edge smoothing feature only if the source quadrangle entirely lies in the source image.

Return Values
ippStsNoErr  
Indicates no error.

ippStsNullPtrErr  
Indicates an error when:
- One of the specified pointers is NULL, excepting pBorderValue
- The value of pBorderValue is NULL when the border type is set to ippBorderConst

ippStsSizeErr  
Indicates an error when width or height of the source or destination image is less than, or equal to one.

ippStsDataTypeErr  
Indicates an error when dataType has an illegal value.

ippStsWarpTransformErr  
Indicates an error when transform has an illegal value.

ippStsQuadErr  
Indicates an error when any of the given quadrangles is non-convex or degenerates into a triangle, line, or point.

ippStsWrongIntersectQuad  
Indicates a warning that no operation is performed if the transformed source image extended with borders has no intersection with the destination image.

ippStsAffineQuadChanged  
Indicates a warning when coordinates of the fourth vertex of dstQuad are changed by the function, if transform is set to ippWarpAffine.

ippStsBorderErr  
Indicates an error when borderType has an illegal value.

ippStsNumChannelsErr  
Indicates an error when numChannels has an illegal value.
See Also

**WarpQuadGetSize** Computes the size of the specification structure and the size of the temporary buffer for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image.

**WarpQuadNearestInit** Initializes the specification structure for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image with the nearest neighbor interpolation method.

**WarpAffineLinear**

*Performs warp affine transformation of an image using the linear interpolation method.*

**Syntax**

```c
IppStatus ippiWarpAffineLinear_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiPoint dstRoiOffset, IppiSize dstRoiSize, const IppiWarpSpec* pSpec, Ipp8u* pBuffer);
```

Supported values for `mod`:

- `8u_C1R` 16u_C1R 16s_C1R 32f_C1R 64f_C1R
- `8u_C3R` 16u_C3R 16s_C3R 32f_C3R 64f_C3R
- `8u_C4R` 16u_C4R 16s_C4R 32f_C4R 64f_C4R

**Platform-aware functions**

```c
IppStatus ippiWarpAffineLinear_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pDst, IppSizeL dstStep, IppiPointL dstRoiOffset, IppiSizeL dstRoiSize, const IppiWarpSpec* pSpec, Ipp8u* pBuffer);
```

Supported values for `mod`:

- `8u_C1R_L` 16u_C1R_L 16s_C1R_L 32f_C1R_L 64f_C1R_L
- `8u_C3R_L` 16u_C3R_L 16s_C3R_L 32f_C3R_L 64f_C3R_L
- `8u_C4R_L` 16u_C4R_L 16s_C4R_L 32f_C4R_L 64f_C4R_L

**Include Files**

ippi.h

Flavors with the `_L` suffix: ippi_l.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- `pSrc` Pointer to the source image.
srcStep  
Distance, in bytes, between the starting points of consecutive lines in the source image buffer.

pDst  
Pointer to the destination image ROI.

dstStep  
Distance, in bytes, between the starting points of consecutive lines in the destination image buffer.

dstRoiOffset  
Offset of the destination image ROI with respect to the destination image origin.

dstRoiSize  
Size of the destination image ROI, in pixels.

pSpec  
Pointer to the specification structure for the warp operation.

pBuffer  
Pointer to the work buffer.

Description
This function transforms the source image pixel coordinates \((x, y)\) according to the following formulas:

\[
x' = c_{00}x + c_{01}y + c_{02} \\
y' = c_{10}x + c_{11}y + c_{12}
\]

where

- \(x'\) and \(y'\) are the pixel coordinates in the transformed image
- \(c_{ij}\) are the affine transform coefficients passed to the \texttt{coeffs} array during initialization

The affine warping is a general linear transform that incorporates such elementary transformations as scaling, rotation, translation, stretching, and shearing. It always transforms parallel lines into parallel lines and preserves equal distances between points on a line.

The \texttt{WarpAffineLinear} function operates with ROI. The transformed part of the image is resampled with the linear interpolation method and stored in the destination image ROI. You need to define the destination image ROI origin by the following parameters: the offset of the destination ROI with respect to the destination image origin and the destination image ROI size. The parameter \texttt{pSrc} must point to the source image origin. The parameter \texttt{pDst} must point to the processed destination image ROI.

If you initialize the specification structure using the \texttt{ippiWarpQuadLinearInit} function, the operations take place only inside the specified source quadrangle \texttt{srcQuad} that is set in \texttt{ippiWarpQuadLinearInit}.

To specify the algorithm for borders processing, set the \texttt{borderType} and \texttt{pBorderValue} parameters when initializing the \texttt{IppiWarpSpec} structure. The data type of \texttt{pBorderValue} is automatically converted from \texttt{Ipp64f} to the data type of the processed images. The function supports the following algorithms for borders processing:

- If the border type is equal to \texttt{ippBorderRepl}, the source image outer pixels are replicated from the edge pixels.
- If the border type is equal to \texttt{ippBorderConst}, the outer pixels are set to the constant value specified in \texttt{pBorderValue}.
- If the border type is equal to \texttt{ippBorderTransp} or \texttt{ippBorderInMem}, destination image pixels mapped to the outer source image pixels are not changed.

Before using the \texttt{ippiWarpAffineLinear} function, you need to initialize the \texttt{IppiWarpSpec} structure using the \texttt{ippiWarpAffineLinearInit} function and compute the size of the external buffer \texttt{pBuffer} using the \texttt{WarpGetBufferSize} function.

To compute the affine transform parameters, use the \texttt{GetAffineQuad}, \texttt{GetAffineBound}, and \texttt{GetAffineTransform} functions.

For an example on how to use this function, refer to the \texttt{WarpQuadNearestInit} function description.
Return Values

ippStsNoErr  
Indicates no error.

ippStsNullPtrErr  
Indicates an error when one of the specified pointers is NULL.

ippStsNoOperation  
Indicates a warning when width or height of the destination image is equal to zero.

ippStsBorderErr  
Indicates an error if border type has an illegal value.

ippStsContextMatchErr  
Indicates an error when context data is invalid.

ippStsNotSupportedModeErr  
Indicates an error when the requested mode is not supported.

ippStsSizeErr  
Indicates an error when width or height of the source or destination image ROI is negative.

ippStsStepErr  
Indicates an error when the step value is not a multiple of data type.

ippStsOutOfRangeErr  
Indicates an error when the destination image offset point is outside the destination image origin.

ippStsSizeWrn  
Indicates a warning when the destination image ROI size is more than the destination image origin size.

ippStsWrongIntersectQuad  
Indicates a warning that no operation is performed if the destination ROI has no intersection with the transformed source image origin.

See Also

ROI Processing in Geometric Transforms
WarpAffineLinearInit  Initializes the specification structure for image affine warping with the linear interpolation method.
WarpQuadLinearInit  Initializes the specification structure for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image with the linear interpolation method.
WarpGetBufferSize  Computes the size of the work buffer for the warp transform.
GetAffineBound  Computes the bounding rectangle for the source ROI transformed by the ippiWarpAffine function.
GetAffineQuad  Computes vertex coordinates of the quadrangle, to which the source ROI rectangle is mapped by the affine transform.
GetAffineTransform  Computes affine transform coefficients to map the source ROI to the quadrangle with the specified vertex coordinates.
WarpQuadNearestInit  Initializes the specification structure for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image with the nearest neighbor interpolation method.

WarpAffineCubicInit
Initializes the specification structure for image affine warping with the cubic interpolation method.

Syntax

IppStatus ippiWarpAffineCubicInit(IppiSize srcSize, IppiSize dstSize, IppDataType dataType, const double coeffs[2][3], IppiWarpDirection direction, int numChannels, Ipp64f valueB, Ipp64f valueC, IppiBorderType borderType, const Ipp64f* pBorderValue, int smoothEdge, IppiWarpSpec* pSpec, Ipp8u* pInitBuf);
Platform-aware functions

IppStatus ippiWarpAffineCubicInit_L(IppiSizeL srcSize, IppiSizeL dstSize, IppDataType dataType, const double coeffs[2][3], IppiWarpDirection direction, int numChannels, Ipp64f valueB, Ipp64f valueC, IppiBorderType borderType, const Ipp64f* pBorderValue, int flags, IppiWarpSpec* pSpec, Ipp8u* pInitBuf);

Include Files

ippi.h

Flavors with the _L suffix: ippi_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

srcSize
Size of the source image, in pixels.

dstSize
Size of the destination image, in pixels.

dataType
Data type of the source and destination images. Supported values: ipp8u, ipp16u, ipp16s, ipp32f, and ipp64f.

coeffs
Coefficients for the affine transform.

direction
Transformation direction. Supported values:
ippWarpForward  Forward transformation
ippWarpBackward  Backward transformation
d

numChannels
Number of channels in the image. Supported values: 1, 3, or 4.

valueB, valueC
The first (B) and second (C) parameter for the cubic filter.

borderType
Type of border. Supported values:
ippBorderConst  Values of all border pixels are set to a constant.
ippBorderRepl  Border is replicated from the edge pixels.
ippBorderTransp  Outer pixels are not processed.
ippBorderInMem  Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderTransp and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.
pBorderValue

Pointer to the constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

flags

Warp algorithm flags. Supported values:

- 0 - transformation without edge smoothing.
- 1 - transformation with edge smoothing. The feature is supported for the ippBorderTransp and ippBorderInMem border types.

smoothEdge

The smooth edge flag. The following values are supported: 0 - transform without edge smoothing, 1 - transform with edge smoothing. This feature is supported only for the ippBorderTransp and ippBorderInMem border types.

pSpec

Pointer to the specification structure.

pInitBuf

Pointer to the temporary buffer for the cubic filter initialization.

Description

This function initializes the IppiWarpSpec structure for the ippiWarpAffineCubic function that performs warp affine transformation with the cubic interpolation method. Before using this function, compute the size of the specification structure and the size of the external buffer pInitBuf using the WarpAffineGetSize function.

Application Notes

Intel IPP warping functions do not support the IPPI_INTER_CUBIC mode. You can use interpolation with two-parameter cubic filters instead. This approach provides the interpolation quality that is comparable with IPPI_INTER_CUBIC. For interpolation formulas refer to Interpolation with Two-Parameter Cubic Filters. You can vary B and C values to get a result that fits the required task.

Return Values

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error when:
  - one of the specified pointers is NULL, excepting pBorderValue
  - pBorderValue is NULL when border type is set to ippBorderConst
- ippStsNoOperation: Indicates a warning if width or height of any image is zero.
- ippStsSizeErr: Indicates an error when width or height of the source or destination image is less than, or equal to one.
- ippStsDataTypeErr: Indicates an error when dataType has an illegal value.
- ippStsWarpDirectionErr: Indicates an error when direction has an illegal value.
- ippStsCoeffErr: Indicates an error when affine transformation is singular.
- ippStsWrongIntersectQuad: Indicates a warning that no operation is performed if the transformed source image extended with borders has no intersection with the destination image.
Indicates an error when the requested mode is not supported. The edge smoothing feature is not supported for the ippBorderRepl and ippBorderConst border types.

Indicates an error when borderType has an illegal value.

Indicates an error when numChannels has an illegal value.

Indicates an error if width or height of the destination image or the source image exceeds 33554431 (0x1FFFFFF).

See Also
WarpAffineGetSize  Computes the size of the specification structure and the size of the external work buffer for the warp affine transform.
Interpolation with Two-Parameter Cubic Filters

WarpQuadCubicInit
Initializes the specification structure for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image with the cubic interpolation method.

Syntax
IppStatus ippiWarpQuadCubicInit(IppiSize srcSize, const double srcQuad[4][2], IppiSize dstSize, const double dstQuad[4][2], IppiWarpTransformType transform, IppDataType dataType, int numChannels, Ipp64f valueB, Ipp64f valueC, IppiBorderType borderType, const Ipp64f* pBorderValue, int smoothEdge, IppiWarpSpec* pSpec, Ipp8u* pInitBuf);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
srcSize
Size of the source image, in pixels.

srcQuad
Quadrangle in the source image.

dstSize
Size of the destination image, in pixels.

dstQuad
Quadrangle in the destination image.

transform
Type of the warp transform. Supported values:
ippWarpAffine  Affine warping
ippWarpPerspective  Perspective warping

dataType
Data type of the source and destination images. Supported values: ipp8u, ipp16u, ipp16s, and ipp32f.

numChannels
Number of channels in the image. Supported values: 1, 3, or 4.

valueB, valueC
The first (B) and second (C) parameter for the cubic filter.
**borderType**

Type of border. Supported values:

- ippBorderTransp: Outer pixels are not processed.
- ippBorderInMem: Border is obtained from the source image pixels in memory.

**pBorderValue**

Pointer to the constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

**smoothEdge**

Flag for edge smoothing. Supported values:

- 0: transformation without edge smoothing.
- 1: transformation with edge smoothing.

**pSpec**

Pointer to the specification structure.

**pInitBuf**

Pointer to the temporary buffer for the cubic filter initialization.

**Description**

This function initializes the IppiWarpSpec structure for warping an arbitrary quadrangle in the source image to quadrangle in the destination image with the cubic interpolation method. Before using this function, compute the size of the specification structure and the size of the external buffer pInitBuf using the WarpQuadGetSize function.

Transformation coefficients are computed internally, based on the mapping of the source quadrangle to the specified destination quadrangle dstQuad and transform type transform. In case of affine transform, the function computes the coordinates of the fourth vertex of the destination quadrangle that uniquely depends on the three other vertices. If the computed coordinates are not equal to the corresponding values specified in dstQuad, the function returns the warning message and continues initialization with the computed values.


For an example on how to use this function, refer to the example provided with the WarpQuadNearestInit function description.

You can apply the edge smoothing feature only if the source quadrangle entirely lies in the source image.

**Return Values**

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error when:
  - One of the specified pointers is NULL, excepting pBorderValue
  - The value of pBorderValue is NULL when the border type is set to ippBorderConst
- ippStsSizeErr: Indicates an error when width or height of the source or destination image is less than, or equal to one.
- ippStsDataTypeErr: Indicates an error when dataType has an illegal value.
- ippStsWarpTransformErr: Indicates an error when transform has an illegal value.
- ippStsQuadErr: Indicates an error when any of the given quadrangles is non-convex or degenerates into a triangle, line, or point.
- ippStsWrongIntersectQuad: Indicates a warning that no operation is performed if the transformed source image extended with borders has no intersection with the destination image.
Indicates a warning when coordinates of the fourth vertex of \( \text{dstQuad} \) are changed by the function, if \( \text{transform} \) is set to \( \text{ippiWarpAffine} \).

Indicates an error when \( \text{borderType} \) has an illegal value.

Indicates an error when \( \text{numChannels} \) has an illegal value.

### See Also
- **WarpQuadGetSize**: Computes the size of the specification structure and the size of the temporary buffer for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image.
- **WarpQuadNearestInit**: Initializes the specification structure for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image with the nearest neighbor interpolation method.

### WarpAffineCubic

**Performs warp affine transformation of an image using the cubic interpolation method.**

### Syntax

```c
IppStatus ippiWarpAffineCubic_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype>* pDst, int dstStep, IppiPoint dstRoiOffset, IppiSize dstRoiSize, const IppiWarpSpec* pSpec, Ipp8u* pBuffer);
```

**Supported values for** \( \text{mod} \):

- 8u_C1R 16u_C1R 16s_C1R 32f_C1R 64f_C1R
- 8u_C3R 16u_C3R 16s_C3R 32f_C3R 64f_C3R
- 8u_C4R 16u_C4R 16s_C4R 32f_C4R 64f_C4R

### Platform-aware functions

```c
IppStatus ippiWarpAffineCubic_<mod>(const Ipp<datatype>* pSrc, IppSizeL srcStep, Ipp<datatype>* pDst, IppSizeL dstStep, IppiPointL dstRoiOffset, IppiSizeL dstRoiSize, const IppiWarpSpec* pSpec, Ipp8u* pBuffer);
```

**Supported values for** \( \text{mod} \):

- 8u_C1R_L 16u_C1R_L 16s_C1R_L 32f_C1R_L 64f_C1R_L
- 8u_C3R_L 16u_C3R_L 16s_C3R_L 32f_C3R_L 64f_C3R_L
- 8u_C4R_L 16u_C4R_L 16s_C4R_L 32f_C4R_L 64f_C4R_L

### Include Files

`ippi.h`

**Flavors with the** \(_L\) **suffix**: `ippi_l.h`

### Domain Dependencies

Headers: `ippcore.h`, `ippvm.h`, `ipps.h`
Parameters

- **pSrc**: Pointer to the source image.
- **srcStep**: Distance, in bytes, between the starting points of consecutive lines in the source image buffer.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance, in bytes, between the starting points of consecutive lines in the destination image buffer.
- **dstRoiOffset**: Offset of the destination image ROI with respect to the destination image origin.
- **dstRoiSize**: Size of the destination image ROI, in pixels.
- **pSpec**: Pointer to the specification structure for the warp operation.
- **pBuffer**: Pointer to the work buffer.

Description

This function transforms the source image pixel coordinates \((x, y)\) according to the following formulas:

\[
\begin{align*}
x' &= c_{00} \cdot x + c_{01} \cdot y + c_{02} \\
y' &= c_{10} \cdot x + c_{11} \cdot y + c_{12}
\end{align*}
\]

where

- \(x'\) and \(y'\) are the pixel coordinates in the transformed image
- \(c_{ij}\) are the affine transform coefficients passed to the `coeffs` array during initialization

The affine warping is a general linear transform that incorporates such elementary transformations as scaling, rotation, translation, stretching, and shearing. It always transforms parallel lines into parallel lines and preserves equal distances between points on a line.

The `WarpAffineCubic` function operates with ROI. The transformed part of the image is resampled with the cubic interpolation method and stored in the destination image ROI. You need to define the destination image ROI by the following parameters: the offset of the destination ROI with respect to the destination image origin and the destination image ROI size. The parameter **pSrc** must point to the source image origin. The parameter **pDst** must point to the processed destination image ROI.

If you initialize the specification structure using the `ippiWarpQuadCubicInit` function, the operations take place only inside the specified source quadrangle \(srcQuad\) that is set in `ippiWarpQuadCubicInit`.

To specify the algorithm for borders processing, set the `borderType` and `pBorderValue` parameters when initialising the IppiWarpSpec structure. The data type of `pBorderValue` is automatically converted from `Ipp64f` to the data type of the processed images. The function supports the following algorithms for borders processing:

- If the border type is equal to `ippBorderRepl`, the source image outer pixels are replicated from the edge pixels.
- If the border type is equal to `ippBorderConst`, the outer pixels are set to the constant value specified in `pBorderValue`.
- If the border type is equal to `ippBorderTransp`, destination image pixels mapped to the outer source image pixels are not changed. The outer pixels required for cubic interpolation are replicated from the edge pixels.
• If the border type is equal to ippBorderInMem, destination image pixels mapped to the outer source image pixels are not changed. The outer pixels required for cubic interpolation are obtained from the out of the source image origin space. Cubic interpolation requires additional one-pixel edge from each source image side.

• The mixed border types can be obtained by the bitwise operation OR between ippBorderTransp and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.

Before using the ippiWarpAffineCubic function, you need to initialize the IppiWarpSpec structure using the ippiWarpAffineCubicInit function and compute the size of the external buffer pBuffer using the WarpGetBufferSize function.

To compute the affine transform parameters, use the GetAffineQuad, GetAffineBound, and GetAffineTransform functions.

For an example on how to use this function, refer to the WarpQuadNearestInit function description.

Return Values

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error when one of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsNoOperation</td>
<td>Indicates a warning when width or height of the destination image is equal to zero.</td>
</tr>
<tr>
<td>ippStsBorderErr</td>
<td>Indicates an error if border type has an illegal value.</td>
</tr>
<tr>
<td>ippStsContextMatchErr</td>
<td>Indicates an error when context data is invalid.</td>
</tr>
<tr>
<td>ippStsNotSupportedModeErr</td>
<td>Indicates an error when width or height of the source or destination image ROI is negative.</td>
</tr>
<tr>
<td>ippStsStepErr</td>
<td>Indicates an error when the step value is not a multiple of data type.</td>
</tr>
<tr>
<td>ippStsOutOfRangeErr</td>
<td>Indicates an error when the destination image offset point is outside the destination image origin.</td>
</tr>
<tr>
<td>ippStsSizeWrn</td>
<td>Indicates a warning when the destination image ROI size is more than the destination image origin size.</td>
</tr>
<tr>
<td>ippStsWrongIntersectQuad</td>
<td>Indicates a warning that no operation is performed, if the transformed source image has no intersection with the destination image.</td>
</tr>
</tbody>
</table>

See Also

ROI Processing in Geometric Transforms
WarpAffineCubicInit  Initializes the specification structure for image affine warping with the cubic interpolation method.
WarpQuadCubicInit    Initializes the specification structure for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image with the cubic interpolation method.
WarpGetBufferSize    Computes the size of the work buffer for the warp transform.
GetAffineBound       Computes the bounding rectangle for the source ROI transformed by the ippiWarpAffine function.
GetAffineQuad        Computes vertex coordinates of the quadrangle, to which the source ROI rectangle is mapped by the affine transform.
GetAffineTransform   Computes affine transform coefficients to map the source ROI to the quadrangle with the specified vertex coordinates.
**WarpQuadNearestInit**  Initializes the specification structure for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image with the nearest neighbor interpolation method.

**GetPerspectiveQuad**
*Computes vertex coordinates of the quadrangle, to which the source ROI rectangle is mapped by the perspective transform.*

**Syntax**

```
IppStatus ippiGetPerspectiveQuad(IppiRect srcRoi, double quad[4][2], const double coeffs[3][3]);
```

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippicore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **srcRoi**  Region of interest in the source image (of the IppiRect type).
- **quad**  Output array. Contains vertex coordinates of the quadrangle, to which the source ROI is mapped by the perspective transform function.
- **coeffs**  The given perspective transform coefficients.

**Description**

This function operates with ROI (see ROI Processing in Geometric Transforms).

This function is used as a support function for the WarpPerspectiveNearest, WarpPerspectiveLinear, and WarpPerspectiveCubic functions. It computes vertex coordinates of the quadrangle, to which the source rectangular ROI is mapped by the perspective transform function using the given coefficients `coeffs`.

The first dimension [4] of the array `quad[4][2]` is equal to the number of vertices, and the second dimension [2] means x and y coordinates of the vertex. Quadrangle vertices have the following meaning:

- `quad[0]` corresponds to the transformed top-left corner of the source ROI,
- `quad[1]` corresponds to the transformed top-right corner of the source ROI,
- `quad[2]` corresponds to the transformed bottom-right corner of the source ROI,
- `quad[3]` corresponds to the transformed bottom-left corner of the source ROI.

**Return Values**

- **ippStsNoErr**  Indicates no error. Any other value indicates an error.
- **ippStsSizeErr**  Indicates an error condition if `srcRoi` has a size field with zero or negative value.
- **ippStsCoeffErr**  Indicates an error condition if coefficient values are invalid.
GetPerspectiveBound

*Computation of the bounding rectangle for the source ROI transformed by the ippiWarpPerspective function.*

**Syntax**

IppStatus ippiGetPerspectiveBound(IppiRect srcRoi, double bound[2][2], const double coeffs[3][3]);

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **srcRoi**
  - Region of interest in the source image (of the IppiRect type).

- **bound**
  - Output array. Contains vertex coordinates of the bounding rectangle for the transformed source ROI.

- **coeffs**
  - The given perspective transform coefficients.

**Description**

This function operates with ROI (see ROI Processing in Geometric Transforms).

This function is used as a support function for the WarpPerspectiveNearest, WarpPerspectiveLinear, and WarpPerspectiveCubic functions. It computes vertex coordinates of the smallest bounding rectangle for the quadrangle quad, to which the source ROI is mapped by the perspective transform function using the given coefficients coeffs.

bound[0] specifies x, y coordinates of the top-left corner, bound[1] specifies x, y coordinates of the bottom-right corner.

**Return Values**

- **ippStsNoErr**
  - Indicates no error. Any other value indicates an error or a warning.

- **ippStsSizeErr**
  - Indicates an error condition if srcRoi has a size field with zero or negative value.

- **ippStsCoeffErr**
  - Indicates an error condition if coefficient values are invalid.

GetPerspectiveTransform

*Computation of the perspective transform coefficients to map the source ROI to the quadrangle with the specified vertex coordinates.*

**Syntax**

IppStatus ippiGetPerspectiveTransform(IppiRect srcRoi, const double quad[4][2], double coeffs[3][3]);
Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
srcRoi  Region of interest in the source image (of the IpplRect type).
quad  Vertex coordinates of the quadrangle, to which the source ROI is mapped by the perspective transform function.
coeffs  Output array. Contains the target perspective transform coefficients.

Description
This function operates with ROI (see ROI Processing in Geometric Transforms).
This function is used as a support function for the WarpPerspectiveNearest, WarpPerspectiveLinear, and WarpPerspectiveCubic functions. It computes the coefficients coeff that should be used by the function to map the source rectangular ROI to the quadrangle with the given vertex coordinates quad.
The first dimension [4] of the array quad[4][2] is equal to the number of vertices, and the second dimension [2] means x and y coordinates of the vertex. Quadrangle vertices have the following meaning:
quad[0] corresponds to the transformed top-left corner of the source ROI,
quad[1] corresponds to the transformed top-right corner of the source ROI,
quad[2] corresponds to the transformed bottom-right corner of the source ROI,
quad[3] corresponds to the transformed bottom-left corner of the source ROI.

Return Values
ippStsNoErr  Indicates no error. Any other value indicates an error.
ippStsSizeErr  Indicates an error condition if srcRoi has a size field with zero or negative value.
ippStsCoeffErr  Indicates an error condition if coefficient values are invalid.
ippStsRectErr  Indicates an error condition if width or height of the srcRoi is less than or equal to 1.

Example
To better understand usage of the ippiGetPerspectiveTransform function, refer to the GetPerspectiveTransform.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

WarpGetRectInfinite
Returns an infinite rectangle.
Syntax
IppiRect ippiWarpGetRectInfinite(void);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Description
The function returns a constant rectangle that is considered as an infinite rectangle by Intel IPP
WarpPerspective functions. Use this rectangle in the following functions: WarpPerspectiveGetSize,
WarpPerspectiveInitNearest, WarpPerspectiveInitLinear, and WarpPerspectiveCubic.

NOTE
The macro definition is: #define ippRectInfinite ippiWarpGetRectInfinite().

WarpPerspectiveGetSize
Computes the size of the specification structure and the size of the external work buffer for the warp
perspective transform.

Syntax
IppStatus ippiWarpPerspectiveGetSize(IppiSize srcSize, IppiRect srcRoi, IppiSize dstSize, IppDataType dataType, const double coeffs[3][3], IppInterpolationType interpolation, IppiWarpDirection direction, IppiBorderType borderType, int* pSpecSize, int* pInitBufSize);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

srcSize

srcRoi

dstSize

dataType

coeffs

Size of the source image, in pixels.
Source image ROI (of the IppiRect type).
Size of the destination image, in pixels.
Data type of the source and destination images.
Supported values: ipp8u, ipp16u, ipp16s, and ipp32f.
Coefficients for the perspective transform.
Interpolation method. Supported values: ippNearest, ippLinear, and ippCubic.

Transformation direction. Supported values:
ippWarpForward  Forward transformation
ippWarpBackward  Backward transformation

Type of border. Supported values:
ippBorderConst  Values of all border pixels are set to a constant.
ippBorderRepl  Border is replicated from the edge pixels.
ippBorderTransp  Outer pixels are not processed.
ippBorderInMem  Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderTransp and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.

Pointer to the size, in bytes, of the specification structure.

Pointer to the size, in bytes, of the temporary buffer.

Description
This function computes the size of the specification structure and the external work buffer for the following functions, depending on the interpolation parameter: ippiWarpPerspectiveNearestInit, ippiWarpPerspectiveLinearInit, or ippiWarpPerspectiveCubicInit.

You can set the value of the srcRoi parameter to ippRectInfinite, which means that the ROI is not specified.

Return Values

ippiStsNoErr  Indicates no error.
ippiStsNullPtrErr  Indicates an error when one of the specified pointers is NULL.
ippiStsSizeErr  Indicates an error in the following cases:
  • If the width or height of the source or destination image is less than, or equal to one.
  • If one of the calculated sizes exceeds the maximum positive 32-bit signed integer value. The size of the one of the processed images is too large.
ippiStsRectErr  Indicates an error in the following cases, if the source image ROI is not ippRectInfinite:
• If the source image ROI has no intersection with the image.
• Either x or y component of the source image ROI is negative.
• Width or height of the source image ROI is less than, or equal to zero.

ippStsDataTypeErr
Indicates an error when dataType has an illegal value.

ippStsWarpDirectionErr
Indicates an error when direction has an illegal value.

ippStsInterpolationErr
Indicates an error when interpolation has an illegal value.

ippStsCoeffErr
Indicates an error when perspective transformation is singular.

ippStsWrongIntersectQuad
Indicates a warning that no operation is performed if the transformed source image extended with borders has no intersection with the destination image.

ippStsBorderErr
Indicates an error when borderType has an illegal value.

ippStsSizeWrn
Indicates a warning when srcRoi exceeds the source image.

See Also
WarpPerspectiveNearestInit Initializes the specification structure for image perspective warping with the nearest neighbor interpolation method.

WarpPerspectiveLinearInit Initializes the specification structure for image perspective warping with the linear interpolation method.

WarpPerspectiveCubicInit Initializes the specification structure for image perspective warping with the cubic interpolation method.

WarpPerspectiveNearestInit
Initializes the specification structure for image perspective warping with the nearest neighbor interpolation method.

Syntax
IppStatus ippiWarpPerspectiveNearestInit(IppiSize srcSize, IppiRect srcRoi, IppiSize dstSize, IppDataType dataType, const double coeffs[3][3], IppiWarpDirection direction, int numChannels, IppiBorderType borderType, const Ipp64f* pBorderValue, int smoothEdge, IppiWarpSpec* pSpec);
**dataType**

Data type of the source and destination images. Supported values: ipp8u, ipp16u, ipp16s, and ipp32f.

**coeffs**

Coefficients for the perspective transform.

**direction**

Transformation direction. Supported values:

- ippWarpForward  Forward transformation
- ippWarpBackward Backward transformation

**numChannels**

Number of channels in the image. Supported values: 1, 3, or 4.

**borderType**

Type of border. Supported values:

- ippBorderConst  Values of all border pixels are set to a constant.
- ippBorderRepl Border is replicated from the edge pixels.
- ippBorderTransp Outer pixels are not processed.
- ippBorderInMem Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderTransp and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.

**pBorderValue**

Pointer to the constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

**smoothEdge**

Flag for edge smoothing. Supported values:

- 0 - transformation without edge smoothing.
- 1 - transformation with edge smoothing. This feature is supported only for the ippBorderTransp and ippBorderInMem border types.

**pSpec**

Pointer to the specification structure.

**Description**

This function initializes the IppiWarpSpec structure for the WarpPerspectiveNearest function that performs warp perspective transformation with the nearest neighbor interpolation method. To compute the size of the specification structure, use the WarpPerspectiveGetSize function.

You can set the value of the srcRoi parameter to ippRectInfinite, which means that the ROI is not specified.
Return Values

ippStsNoErr
Indicates no error.

ippStsNullPtrErr
Indicates an error when:
- \texttt{pSpec} is \texttt{NULL}
- \texttt{pBorderValue} is \texttt{NULL} when the border type is set to ippBorderConst

ippStsSizeErr
Indicates an error when width or height of the source or destination image is less than, or equal to one.

ippStsRectErr
Indicates an error in the following cases, if the source image ROI is not ippRectInfinite:
- If the source image ROI has no intersection with the image.
- Either \texttt{x} or \texttt{y} component of the source image ROI is negative.
- Width or height of the source image ROI is less than, or equal to zero.

ippStsDataTypeErr
Indicates an error when \texttt{dataType} has an illegal value.

ippStsWarpDirectionErr
Indicates an error when \texttt{direction} has an illegal value.

ippStsCoeffErr
Indicates an error when perspective transformation is singular.

ippStsWrongIntersectQuad
Indicates a warning that no operation is performed if the transformed source image extended with borders has no intersection with the destination image.

ippStsNotSupportedModeErr
Indicates an error when the requested mode is not supported. The edge smoothing feature is not supported for the ippBorderRepl and ippBorderConst border types.

ippStsBorderErr
Indicates an error when \texttt{borderType} has an illegal value.

ippStsNumChannelsErr
Indicates an error when \texttt{numChannels} has an illegal value.

ippStsSizeWrn
Indicates a warning when \texttt{srcRoi} exceeds the source image.

See Also

WarpPerspectiveGetSize
Computes the size of the specification structure and the size of the external work buffer for the warp perspective transform.

WarpPerspectiveNearest
Performs warp perspective transformation of an image using the nearest neighbor interpolation method.

Syntax

\texttt{IppStatus ippiWarpPerspectiveNearest_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype> pDst, int dstStep, IppiPoint dstRoiOffset, IppiSize dstRoiSize, const IppiWarpSpec* pSpec, Ipp8u* pBuffer);}

Supported values for \texttt{mod}:

8u\_C1R \hspace{1cm} 16u\_C1R \hspace{1cm} 16s\_C1R \hspace{1cm} 32f\_C1R
Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pSrc
Pointer to the source image.

srcStep
Distance, in bytes, between the starting points of consecutive lines in the source image buffer.

pDst
Pointer to the destination image ROI.

dstStep
Distance, in bytes, between the starting points of consecutive lines in the destination image buffer.

dstRoiOffset
Offset of the destination image ROI with respect to the destination image origin.

dstRoiSize
Size of the destination image ROI, in pixels.

pSpec
Pointer to the specification structure for the warp operation.

pBuffer
Pointer to the work buffer.

Description
This function transforms the source image pixel coordinates \((x, y)\) according to the following formulas:

\[
\begin{align*}
x' &= (c_{00}x + c_{01}y + c_{02})/ (c_{20}x + c_{21}y + c_{22}) \\
y' &= (c_{10}x + c_{11}y + c_{12})/ (c_{20}x + c_{21}y + c_{22})
\end{align*}
\]

where

- \(x'\) and \(y'\) are the pixel coordinates in the transformed image
- \(c_{ij}\) are the affine transform coefficients passed to the \texttt{coeffs} array during initialization

The \texttt{ippiWarpPerspectiveNearest} function operates with ROI (see Regions of Interest in Intel IPP). The transformed part of the source image is resampled with the nearest neighbor interpolation method and stored in the destination image ROI. You need to define the destination image ROI origin by the following parameters: the offset of the destination ROI with respect to the destination image origin and the destination image ROI size. The parameter \texttt{pDst} must point to the processed destination image ROI.

If you initialize the warp specification structure using the \texttt{WarpPerspectiveNearestInit} function, you can specify the source image ROI in the following ways:

- Set the \texttt{srcRoi} value to \texttt{ippRectInfinite}, which means that the ROI is not specified. In this case, \texttt{pSrc} must point to the processed source image. Pixels that are outside the source image boundaries are computed according to the specified border type.
- Set the \texttt{srcRoi} value to the part of the processed source image. In this case, \texttt{pSrc} must point to the processed source image ROI. The operations take place only inside the specified region of interest \texttt{srcRoi}. It means that the destination image pixels mapped to the outer pixels of the specified source image region are not changed.
If you initialize the warp specification structure using the `WarpQuadNearestInit` function, set the `pSrc` value to the processed source image. The operations take place only inside the source quadrangle `srcQuad` that is specified in the `WarpQuadNearestInit` function.

To specify the algorithm for borders processing, set the `borderType` and `pBorderValue` parameters when initializing the `IppiWarpSpec` structure. The data type of `borderValue` is automatically converted from `Ipp64f` to the data type of the processed images. The function supports the following algorithms for borders processing:

- If the border type is equal to `ippBorderRepl`, the source image outer pixels are replicated from the edge pixels.
- If the border type is equal to `ippBorderConst`, the outer pixels are set to the constant value specified in `pBorderValue`.
- If the border type is equal to `ippBorderTransp` or `ippBorderInMem`, destination image pixels mapped to the outer source image pixels are not changed.

Before using the `ippiWarpPerspectiveNearest` function, you need to initialize the `IppiWarpSpec` structure using the `WarpPerspectiveNearestInit` function and compute the size of the external buffer `pBuffer` using the `WarpGetBufferSize` function.

To compute the perspective transform parameters, use the `GetPerspectiveQuad`, `GetPerspectiveBound`, and `GetPerspectiveTransform` functions.

**Return Values**

- `ippStsNoErr` Indicates no error.
- `ippStsNullPtrErr` Indicates an error when one of the specified pointers is `NULL`.
- `ippStsNoOperation` Indicates a warning when width or height of the destination image is equal to zero.
- `ippStsContextMatchErr` Indicates an error when context data is invalid.
- `ippStsNotSupportedModeErr` Indicates an error when the requested mode is not supported.
- `ippStsSizeErr` Indicates an error when width or height of the source or destination image ROI is negative.
- `ippStsStepErr` Indicates an error when the step value is not a multiple of data type.
- `ippStsOutOfRangeErr` Indicates an error when the destination image offset point is outside the destination image origin.
- `ippStsSizeWrn` Indicates a warning when the destination image ROI size is more than the destination image origin size.
- `ippStsWrongIntersectQuad` Indicates a warning that no operation is performed if the transformed source image extended with borders has no intersection with the destination image.

**Example**

To better understand usage of Intel IPP functionality for perspective warping with Nearest Neighbor, Linear, and Cubic interpolation modes, refer to the `WarpPerspectiveNearest.c` example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

**See Also**

- ROI Processing in Geometric Transforms
- `WarpPerspectiveNearestInit` Initializes the specification structure for image perspective warping with the nearest neighbor interpolation method.
**WarpQuadNearestInit**  Initializes the specification structure for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image with the nearest neighbor interpolation method.

**WarpGetBufferSize**  Computes the size of the work buffer for the warp transform.

**GetPerspectiveBound**  Computes the bounding rectangle for the source ROI transformed by the ippiWarpPerspective function.

**GetPerspectiveQuad**  Computes vertex coordinates of the quadrangle, to which the source ROI rectangle is mapped by the perspective transform.

**GetPerspectiveTransform**  Computes the perspective transform coefficients to map the source ROI to the quadrangle with the specified vertex coordinates.

**WarpPerspectiveLinearInit**  
Initializes the specification structure for image perspective warping with the linear interpolation method.

### Syntax

```
IppStatus ippiWarpPerspectiveLinearInit(IppiSize srcSize, IppiRect srcRoi, IppiSize dstSize, IppDataType dataType, const double coeffs[3][3], IppiWarpDirection direction, int numChannels, IppiBorderType borderType, const Ipp64f* pBorderValue, int smoothEdge, IppiWarpSpec* pSpec);
```

### Include Files

ippi.h

### Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

### Parameters

- **srcSize**  Size of the source image, in pixels.
- **srcRoi**  Source image ROI (of the IppiRect type).
- **dstSize**  Size of the destination image, in pixels.
- **dataType**  Data type of the source and destination images. Supported values: ipp8u, ipp16u, ipp16s, and ipp32f.
- **coeffs**  Coefficients for the perspective transform.
- **direction**  Transformation direction. Supported values:
  - ippWarpForward  Forward transformation
  - ippWarpBackward  Backward transformation
- **numChannels**  Number of channels in the image. Supported values: 1, 3, or 4.
- **borderType**  Type of border. Supported values:
  - ippBorderConst  Values of all border pixels are set to a constant.
ippBorderRepl  Border is replicated from the edge pixels.

ippBorderTransp Outer pixels are not processed.

ippBorderInMem Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderTransp and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.

pBorderValue Pointer to the constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

smoothEdge Flag for edge smoothing. Supported values:

- 0 - transformation without edge smoothing.
- 1 - transformation with edge smoothing. This feature is supported only for the ippBorderTransp and ippBorderInMem border types.

pSpec Pointer to the specification structure.

Description

This function initializes the IppiWarpSpec structure for the ippiWarpPerspectiveLinear function that performs warp perspective transformation with the linear interpolation method. To compute the size of the specification structure, use the WarpPerspectiveGetSize function.

You can set the value of the srcRoi parameter to ippRectInfinite, which means that the ROI is not specified.

Return Values

ippStsNoErr Indicates no error.

ippStsNullPtrErr Indicates an error when:

- pSpec is NULL
- pBorderValue is NULL when the border type is set to ippBorderConst

ippStsSizeErr Indicates an error when width or height of the source or destination image is less than, or equal to one.

ippStsRectErr Indicates an error in the following cases, if the source image ROI is not ippRectInfinite:

- If the source image ROI has no intersection with the image.
- Either x or y component of the source image ROI is negative.
- Width or height of the source image ROI is less than, or equal to zero.
Indicates an error when $dataType$ has an illegal value.

Indicates an error when $direction$ has an illegal value.

Indicates an error when perspective transformation is singular.

Indicates a warning that no operation is performed if the transformed source image extended with borders has no intersection with the destination image.

Indicates an error when the requested mode is not supported. The edge smoothing feature is not supported for the ippBorderRepl and ippBorderConst border types.

Indicates an error when $borderType$ has an illegal value.

Indicates an error when $numChannels$ has an illegal value.

Indicates a warning when $srcRoi$ exceeds the source image.

**See Also**

WarpPerspectiveGetSize  Computes the size of the specification structure and the size of the external work buffer for the warp perspective transform.

WarpPerspectiveLinear  Performs warp perspective transformation of an image using the linear interpolation method.

**Syntax**

```c
IppStatus ippiWarpPerspectiveLinear_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype> pDst, int dstStep, IppiPoint dstRoiOffset, IppiSize dstRoiSize, const IppiWarpSpec* pSpec, Ipp8u* pBuffer);
```

Supported values for $mod$:  

<table>
<thead>
<tr>
<th></th>
<th>8u_C1R</th>
<th>16u_C1R</th>
<th>16s_C1R</th>
<th>32f_C1R</th>
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<tr>
<td>32f_C4R</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Include Files**

ippi.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

$pSrc$  
Pointer to the source image.

$srcStep$  
Distance, in bytes, between the starting points of consecutive lines in the source image buffer.
**pDst**
Pointer to the destination image ROI.

**dstStep**
Distance, in bytes, between the starting points of consecutive lines in the destination image buffer.

**dstRoiOffset**
Offset of the destination image ROI with respect to the destination image origin.

**dstRoiSize**
Size of the destination image ROI, in pixels.

**pSpec**
Pointer to the specification structure for the warp operation.

**pBuffer**
Pointer to the work buffer.

### Description
This function transforms the source image pixel coordinates \((x, y)\) according to the following formulas:

\[
x' = \frac{(c_{00} \cdot x + c_{01} \cdot y + c_{02})}{(c_{20} \cdot x + c_{21} \cdot y + c_{22})}
\]

\[
y' = \frac{(c_{10} \cdot x + c_{11} \cdot y + c_{12})}{(c_{20} \cdot x + c_{21} \cdot y + c_{22})}
\]

where

- \(x'\) and \(y'\) are the pixel coordinates in the transformed image
- \(c_{ij}\) are the affine transform coefficients passed to the `coeffs` array during initialization

The `ippiWarpPerspectiveLinear` function operates with ROI (see Regions of Interest in Intel IPP). The transformed part of the source image is resampled with the linear interpolation method and stored in the destination image ROI. You need to define the destination image ROI origin by the following parameters: the offset of the destination ROI with respect to the destination image origin and the destination image ROI size. The parameter `pDst` must point to the processed destination image ROI.

If you initialize the warp specification structure using the `ippiWarpPerspectiveLinearInit` function, you can specify the source image ROI in the following ways:

- Set the `srcRoi` value to `ippRectInfinite`, which means that the ROI is not specified. In this case, `pSrc` must point to the processed source image. Pixels that are outside the source image boundaries are computed according to the specified border type.
- Set the `srcRoi` value to the part of the processed source image. In this case, `pSrc` must point to the processed source image ROI. The operations take place only inside the specified region of interest `srcRoi`. It means that the destination image pixels mapped to the outer pixels of the specified source image region are not changed.

If you initialize the warp specification structure using the `ippiWarpQuadLinearInit` function, set the `pSrc` value to the processed source image. The operations take place only inside the source quadrangle `srcQuad` that is specified in the `ippiWarpQuadLinearInit` function.

To specify the algorithm for borders processing, set the `borderType` and `pBorderValue` parameters when initializing the `IppiWarpSpec` structure. The data type of `pBorderValue` is automatically converted from `Ipp64f` to the data type of the processed images. The function supports the following algorithms for borders processing:

- If the border type is equal to `ippBorderRepl`, the source image outer pixels are replicated from the edge pixels.
- If the border type is equal to `ippBorderConst`, the outer pixels are set to the constant value specified in `pBorderValue`.
- If the border type is equal to `ippBorderTransp` or `ippBorderInMem`, destination image pixels mapped to the outer source image pixels are not changed.
Before using the `ippiWarpPerspectiveLinear` function, you need to initialize the `IppiWarpSpec` structure using the `ippiWarpPerspectiveLinearInit` function and compute the size of the external buffer `pBuffer` using the `ippiWarpGetBufferSize` function.

To compute the perspective transform parameters, use the `ippiGetPerspectiveQuad`, `ippiGetPerspectiveBound`, and `ippiGetPerspectiveTransform` functions.

For an example on how to use this functionality, refer to the example provided with the `ippiWarpPerspectiveNearest` function description.

**Return Values**

- `ippStsNoErr`: Indicates no error.
- `ippStsNullPtrErr`: Indicates an error when one of the specified pointers is `NULL`.
- `ippStsNoOperation`: Indicates a warning when width or height of the destination image is equal to zero.
- `ippStsContextMatchErr`: Indicates an error when context data is invalid.
- `ippStsNotSupportedModeErr`: Indicates an error when the requested mode is not supported.
- `ippStsSizeErr`: Indicates an error when width or height of the source or destination image ROI is negative.
- `ippStsStepErr`: Indicates an error when the step value is not a multiple of data type.
- `ippStsOutOfRangeErr`: Indicates an error when the destination image offset point is outside the destination image origin.
- `ippStsSizeWrn`: Indicates a warning when the destination image ROI size is more than the destination image origin size.
- `ippStsWrongIntersectQuad`: Indicates a warning that no operation is performed if the transformed source image extended with borders has no intersection with the destination image.

**See Also**

ROI Processing in Geometric Transforms

- `WarpPerspectiveLinearInit`: Initializes the specification structure for image perspective warping with the linear interpolation method.
- `WarpQuadLinearInit`: Initializes the specification structure for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image with the linear interpolation method.
- `WarpGetBufferSize`: Computes the size of the work buffer for the warp transform.
- `GetPerspectiveBound`: Computes the bounding rectangle for the source ROI transformed by the `ippiWarpPerspective` function.
- `GetPerspectiveQuad`: Computes vertex coordinates of the quadrangle, to which the source ROI rectangle is mapped by the perspective transform.
- `GetPerspectiveTransform`: Computes the perspective transform coefficients to map the source ROI to the quadrangle with the specified vertex coordinates.
- `WarpPerspectiveNearest`: Performs warp perspective transformation of an image using the nearest neighbor interpolation method.

**WarpPerspectiveCubicInit**

Initializes the specification structure for image perspective warping with the cubic interpolation method.
Syntax

IppStatus ippiWarpPerspectiveCubicInit(IppiSize srcSize, IppRect srcRoi, IppiSize dstSize, IppDataType dataType, const double coeffs[3][3], IppiWarpDirection direction, int numChannels, Ipp64f valueB, Ipp64f valueC, IppiBorderType borderType, const Ipp64f* pBorderValue, int smoothEdge, IppiWarpSpec* pSpec, Ipp8u* pInitBuf);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipp.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

srcSize

Size of the source image, in pixels.

Source image ROI (of the IppiRect type).

dstSize

Size of the destination image, in pixels.

dataType

Data type of the source and destination images. Supported values: ipp8u, ipp16u, ipp16s, and ipp32f.

coeffs

Coefficients for the perspective transform.

direction

Transformation direction. Supported values:

ippWarpForward Forward transformation
ippWarpBackwar Backward transformation

numChannels

Number of channels in the image. Supported values: 1, 3, or 4.

valueB, valueC

The first (B) and second (C) parameter for the cubic filter.

borderType

Type of border. Supported values:

ippBorderConst Values of all border pixels are set to a constant.
ippBorderRepl Border is replicated from the edge pixels.
ippBorderTransp Outer pixels are not processed.
ippBorderInMem Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderTransp and the ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight values.
**pBorderValue**

Pointer to the constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

**smoothEdge**

Flag to enable/disable edge smoothing. Possible values: 0 - transform without edge smoothing, 1 - transform with edge smoothing. This feature is supported only for the ippBorderTransp and ippBorderInMem border types.

**pSpec**

Pointer to the specification structure.

**pInitBuf**

Pointer to the temporary buffer for the cubic filter initialization.

**Description**

This function initializes the IppiWarpSpec structure for the ippiWarpPerspectiveCubic function that performs that performs warp perspective transformation with the cubic interpolation method. Before using this function, compute the size of the specification structure and the size of the external buffer pInitBuf using the WarpPerspectiveGetSize function.

You can set the value of the srcRoi parameter to ippRectInfinite, which means that the ROI is not specified.

**Return Values**

- **ippStsNoErr**
  
  Indicates no error.

- **ippStsNullPtrErr**
  
  Indicates an error when:
  
  - pSpec is NULL
  
  - pBorderValue is NULL when the border type is set to ippBorderConst

- **ippStsSizeErr**
  
  Indicates an error when width or height of the source or destination image is less than, or equal to one.

- **ippStsRectErr**
  
  Indicates an error in the following cases, if the source image ROI is not ippRectInfinite:

  - If the source image ROI has no intersection with the image.
  
  - Either x or y component of the source image ROI is negative.
  
  - Width or height of the source image ROI is less than, or equal to zero.

- **ippStsDataTypeErr**
  
  Indicates an error when dataType has an illegal value.

- **ippStsWarpDirectionErr**
  
  Indicates an error when direction has an illegal value.

- **ippStsCoeffErr**
  
  Indicates an error when perspective transformation is singular.

- **ippStsWrongIntersectQuad**
  
  Indicates a warning that no operation is performed if the transformed source image extended with borders has no intersection with the destination image.

- **ippStsNotSupportedModeErr**
  
  Indicates an error when the requested mode is not supported. The edge smoothing feature is not supported for the ippBorderRepl and ippBorderConst border types.

- **ippStsBorderErr**
  
  Indicates an error when borderType has an illegal value.
ippStsNumChannelsErr
Indicates an error when numChannels has an illegal value.

ippStsSizeWrn
Indicates a warning when srcRoi exceeds the source image.

See Also
WarpPerspectiveGetSize Computes the size of the specification structure and the size of the external work buffer for the warp perspective transform.

WarpPerspectiveCubic Performs warp perspective transformation of an image using the cubic interpolation method.

Syntax
IppStatus ippiWarpPerspectiveCubic_<mod>(const Ipp<datatype>* pSrc, int srcStep, Ipp<datatype> pDst, int dstStep, IppiPoint dstRoiOffset, IppiSize dstRoiSize, const IppiWarpSpec* pSpec, Ipp8u* pBuffer);

Supported values for mod:

<table>
<thead>
<tr>
<th>8u_C1R</th>
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<th>16s_C1R</th>
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<td>32f_C4R</td>
</tr>
</tbody>
</table>

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pSrc
Pointer to the source image.
srcStep
Distance, in bytes, between the starting points of consecutive lines in the source image buffer.
pDst
Pointer to the destination image ROI.
dstStep
Distance, in bytes, between the starting points of consecutive lines in the destination image buffer.
dstRoiOffset
Offset of the destination image ROI with respect to the destination image origin.
dstRoiSize
Size of the destination image ROI, in pixels.
pSpec
Pointer to the specification structure for the warp operation.
pBuffer
Pointer to the work buffer.
Description
This function transforms the source image pixel coordinates \((x, y)\) according to the following formulas:
\[
\begin{align*}
x' &= \frac{(c_{00}x + c_{01}y + c_{02})}{(c_{20}x + c_{21}y + c_{22})} \\
y' &= \frac{(c_{10}x + c_{11}y + c_{12})}{(c_{20}x + c_{21}y + c_{22})}
\end{align*}
\]
where
- \(x'\) and \(y'\) are the pixel coordinates in the transformed image
- \(c_{ij}\) are the affine transform coefficients passed to the \(coeffs\) array during initialization

The \texttt{ippiWarpPerspectiveCubic} function operates with ROI (see Regions of Interest in Intel IPP). The transformed part of the source image is resampled with the cubic interpolation method and stored in the destination image ROI. You need to define the destination image ROI origin by the following parameters: the offset of the destination ROI with respect to the destination image origin and the destination image ROI size. The parameter \(pDst\) must point to the processed destination image ROI.

If you initialize the warp specification structure using the \texttt{ippiWarpPerspectiveCubicInit} function, you can specify the source image ROI in the following ways:
- Set the \(srcRoi\) value to \texttt{ippRectInfinite}, which means that the ROI is not specified. In this case, \(pSrc\) must point to the processed source image. Pixels that are outside the source image boundaries are computed according to the specified border type.
- Set the \(srcRoi\) value to the part of the processed source image. In this case, \(pSrc\) must point to the processed source image ROI. The operations take place only inside the specified region of interest \(srcRoi\). It means that the destination image pixels mapped to the outer pixels of the specified source image region are not changed.

If you initialize the warp specification structure using the \texttt{ippiWarpQuadCubicInit} function, set the \(pSrc\) value to the processed source image. The operations take place only inside the source quadrangle \(srcQuad\) that is specified in the \texttt{ippiWarpQuadCubicInit} function.

To specify the algorithm for borders processing, set the \(borderType\) and \(pBorderValue\) parameters when initializing the \texttt{IppiWarpSpec} structure. The data type of \(pBorderValue\) is automatically converted from \texttt{Ipp64f} to the data type of the processed images. The function supports the following algorithms for borders processing:
- If the border type is equal to \texttt{ippBorderRepl}, the source image outer pixels are replicated from the edge pixels.
- If the border type is equal to \texttt{ippBorderConst}, the outer pixels are set to the constant value specified in \(pBorderValue\).
- If the border type is equal to \texttt{ippBorderTransp}, destination image pixels mapped to the outer source image pixels are not changed. The outer pixels required for cubic interpolation are replicated from the edge pixels.
- If the border type is equal to \texttt{ippBorderInMem}, destination image pixels mapped to the outer source image pixels are not changed. The outer pixels required for cubic interpolation are obtained from the out of the source image origin space. Cubic interpolation requires additional one-pixel edge from each source image side.
- The mixed border types can be obtained by the bitwise operation \texttt{OR} between \texttt{ippBorderTransp} and the \texttt{ippBorderInMemTop}, \texttt{ippBorderInMemBottom}, \texttt{ippBorderInMemLeft}, \texttt{ippBorderInMemRight} values

Before using the \texttt{ippiWarpPerspectiveCubic} function, you need to initialize the \texttt{IppiWarpSpec} structure using the \texttt{ippiWarpPerspectiveCubicInit} function and compute the size of the external buffer \(pBuffer\) using the \texttt{ippiWarpGetBufferSize} function.

To compute the perspective transform parameters, use the \texttt{ippiGetPerspectiveQuad}, \texttt{ippiGetPerspectiveBound}, and \texttt{ippiGetPerspectiveTransform} functions.
For an example on how to use this functionality, refer to the example provided with the `ippiWarpPerspectiveNearest` function description.

**Return Values**

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error when one of the specified pointers is `NULL`.
- **ippStsNoOperation**: Indicates a warning when width or height of the destination image is equal to zero.
- **ippStsContextMatchErr**: Indicates an error when context data is invalid.
- **ippStsNotSupportedModeErr**: Indicates an error when the requested mode is not supported.
- **ippStsSizeErr**: Indicates an error when width or height of the source or destination image ROI is negative.
- **ippStsStepErr**: Indicates an error when the step value is not a multiple of data type.
- **ippStsOutOfRangeErr**: Indicates an error when the destination image offset point is outside the destination image origin.
- **ippStsSizeWrn**: Indicates a warning when the destination image ROI size is more than the destination image origin size.
- **ippStsWrongIntersectQuad**: Indicates a warning that no operation is performed if the transformed source image extended with borders has no intersection with the destination image.

**See Also**

- **ROI Processing in Geometric Transforms**
- **WarpPerspectiveCubicInit**: Initializes the specification structure for image perspective warping with the cubic interpolation method.
- **WarpQuadCubicInit**: Initializes the specification structure for warping an arbitrary quadrangle in the source image to the quadrangle in the destination image with the cubic interpolation method.
- **WarpGetBufferSize**: Computes the size of the work buffer for the warp transform.
- **GetPerspectiveBound**: Computes the bounding rectangle for the source ROI transformed by the `ippiWarpPerspective` function.
- **GetPerspectiveQuad**: Computes vertex coordinates of the quadrangle, to which the source ROI rectangle is mapped by the perspective transform.
- **GetPerspectiveTransform**: Computes the perspective transform coefficients to map the source ROI to the quadrangle with the specified vertex coordinates.
- **WarpPerspectiveNearest**: Performs warp perspective transformation of an image using the nearest neighbor interpolation method.

**GetBilinearQuad**

*Computes the vertex coordinates of the quadrangle, to which the source rectangular ROI is mapped by the bilinear transform.*

**Syntax**

```c
IppStatus ippiGetBilinearQuad(IppiRect srcRoi, double quad[4][2], const double coeffs[2][4]);
```
Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

srcRoi
Region of interest in the source image (of the IppiRect type).

quad
Output array. Contains vertex coordinates of the quadrangle, to which the source ROI is mapped by the bilinear transform function.

coeffs
The given bilinear transform coefficients.

Description
This function operates with ROI (see ROI Processing in Geometric Transforms).
This function is used as a support function forippiWarpBilinear. It computes vertex coordinates of the quadrangle, to which the source rectangular ROI is mapped by the bilinear transform functionippiWarpBilinear using coefficients coeffs.
The first dimension [4] of the array quad[4][2] is equal to the number of vertices, and the second dimension [2] means x and y coordinates of the vertex. Quadrangle vertices have the following meaning:
quad[0] corresponds to the transformed top-left corner of the source ROI,
quad[1] corresponds to the transformed top-right corner of the source ROI,
quad[2] corresponds to the transformed bottom-right corner of the source ROI,
quad[3] corresponds to the transformed bottom-left corner of the source ROI.

Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error.

ippStsSizeErr
Indicates an error condition if srcRoi has a size field with zero or negative value.

ippStsCoeffErr
Indicates an error condition if coefficient values are invalid.

GetBilinearBound
Computes the bounding rectangle for the source ROI transformed by theippiWarpBilinear function.

Syntax
IppStatus ippiGetBilinearBound(IppiRect srcRoi, double bound[2][2], const double coeffs[2][4]);

Include Files
ippi.h
Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

srcRoi Region of interest in the source image (of the IppiRect type).
bound Output array. Contains vertex coordinates of the bounding rectangle for the transformed source ROI.
The given bilinear transform coefficients.

desc

Description
This function operates with ROI (see ROI Processing in Geometric Transforms).
This function is used as a support function for ippiWarpBilinear. It computes vertex coordinates of the smallest bounding rectangle for the quadrangle quad, to which the source ROI is mapped by the bilinear transform function ippiWarpBilinear using coefficients coeffs.

bound[0] specifies x, y coordinates of the top-left corner, bound[1] specifies x, y coordinates of the bottom-right corner.

Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsSizeErr Indicates an error condition if srcRoi has a size field with zero or negative value.
ippStsCoeffErr Indicates an error condition if coefficient values are invalid.

GetBilinearTransform
Computes bilinear transform coefficients to map the source ROI to the quadrangle with the specified vertex coordinates.

Syntax
IppStatus ippiGetBilinearTransform(IppiRect srcRoi, const double quad[4][2], double coeffs[2][4]);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

srcRoi Region of interest in the source image (of the IppiRect type).
quad

Vertex coordinates of the quadrangle, to which the source ROI is mapped by the bilinear transform function.

coeffs

Output array. Contains the target bilinear transform coefficients.

Description

This function operates with ROI (see ROI Processing in Geometric Transforms).

This function is used as a support function for ippiWarpBilinear. It computes the coefficients coeffs of the bilinear transform that maps the source rectangular ROI to the quadrangle with the specified vertex coordinates quad.

The first dimension [4] of the array quad[4][2] is equal to the number of vertices, and the second dimension [2] means x and y coordinates of the vertex. Quadrangle vertices have the following meaning:

quad[0] corresponds to the transformed top-left corner of the source ROI,
quad[1] corresponds to the transformed top-right corner of the source ROI,
quad[2] corresponds to the transformed bottom-right corner of the source ROI,
quad[3] corresponds to the transformed bottom-left corner of the source ROI.

Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error.

ippStsSizeErr
Indicates an error condition if srcRoi has a size field with zero or negative value.

ippStsCoeffErr
Indicates an error condition if coefficient values are invalid.

ippStsRectErr
Indicates an error condition if width or height of the srcRoi is less than or equal to 1.

Example

To better understand usage of the ippiGetBilinearTransform function, refer to the GetBilinearTransform.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

WarpBilinearGetBufferSize

Computes the size of the work buffer for bilinear warping.

Syntax

IppStatus ippiWarpBilinearGetBufferSize(IppSize srcSize, IppRect srcRoi, IppRect dstRoi, IppiWarpDirection direction, const double coeffs[2][4], int interpolation, int* pBufSize);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

srcSize
Size of the source image, in pixels.

srcRoi
Source image ROI (of the IppiRect type).

dstRoi
Destination image ROI (of the IppiRect type).

direction
Transformation direction. Supported values:
ippWarpForward Forward transformation
ippWarpBackward Backward transformation

coeffs
Coefficients for the perspective transform.

interpolation
Interpolation mode. Supported values:
IPPI_INTER_NN Nearest neighbor interpolation
IPPI_INTER_LINEAR Linear interpolation
IPPI_INTER_CUBIC Cubic interpolation
IPPI_INTER_EDGE Use edge smoothing in addition to one of the above modes

pBufSize
Pointer to the size, in bytes, of the external buffer.

Description
This function computes the size of the external work buffer required for bilinear warping of the source image ROI. The result is stored in the pBufSize parameter.

Return Values

ippStsNoErr Indicates no error.
ippStsNullPtrErr Indicates an error when pBufSize is NULL.
ippStsSizeErr Indicates an error when one of the image dimensions is less than, or equal to zero.
ippStsWarpDirectionErr Indicates an error when direction has an illegal value.
ippStsCoeffErr Indicates an error when bilinear transformation is singular.
ippStsInterpolationErr Indicates an error when interpolation has an illegal value.
ippStsWrongIntersectQuad Indicates a warning that no operation is performed if the transformed source image extended with borders has no intersection with the destination image.

See Also
WarpBilinear MODIFIED API. Performs bilinear warping of the source image using the specified transform coefficients.

WarpBilinear
MODIFIED API. Performs bilinear warping of the source image using the specified transform coefficients.
Syntax

IppStatus ippiWarpBilinear_\texttt{mod}(const Ipp\langle\texttt{datatype}\rangle^{*} pSrc, IppSize srcSize, int srcStep, IppiRect srcRoi, Ipp\langle\texttt{datatype}\rangle^{*} pDst, int dstStep, IppiRect dstRoi, const double coeffs[2][4], int interpolation, Ipp8u* pBuffer);

Supported values for \texttt{mod}:

- 8u_C1R
- 16u_C1R
- 32f_C1R
- 8u_C3R
- 16u_C3R
- 32f_C3R
- 8u_C4R
- 16u_C4R
- 32f_C4R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- \texttt{pSrc}
  - Pointer to the source image origin. An array of separate pointers to each plane in case of data in planar format.
  - Size in pixels of the source image.
  - Distance in bytes between starts of consecutive lines in the source image buffer.
  - Region of interest in the source image (of the IppiRect type).

- \texttt{srcSize}

- \texttt{srcStep}

- \texttt{srcRoi}

- \texttt{pDst}
  - Pointer to the destination image origin. An array of separate pointers to each plane in case of data in planar format.
  - Distance in bytes between starts of consecutive lines in the destination image buffer.
  - Region of interest in the destination image (of the IppiRect type).

- \texttt{dstStep}

- \texttt{dstRoi}

- \texttt{coeffs}
  - The bilinear transform coefficients.

- \texttt{interpolation}
  - Specifies the interpolation mode. Use one of the following values:
    - IPPI\_INTER\_NN Nearest neighbor interpolation
    - IPPI\_INTER\_LINEAR Linear interpolation
    - IPPI\_INTER\_CUBIC Cubic interpolation
Use edge smoothing in addition to one of the above modes.

Pointer to the external work buffer.

**Description**

**Important** The API of this function has been modified in Intel IPP 9.0 release.

This function operates with ROI (see ROI Processing in Geometric Transforms).

This bilinear warp function transforms the source image pixel coordinates \((x,y)\) according to the following formulas:

\[
x' = c_{00} \cdot x \cdot y + c_{01} \cdot x + c_{02} \cdot y + c_{03}
\]

\[
y' = c_{10} \cdot x \cdot y + c_{11} \cdot x + c_{12} \cdot y + c_{13}
\]

where \(x'\) and \(y'\) denote the pixel coordinates in the transformed image, and \(c_{ij}\) are the bilinear transform coefficients passed in the array \(coeffs\).

The bilinear transform preserves equal distances between points on a line.

The transformed part of the source image is resampled using the interpolation mode specified by the `interpolation` parameter, and written to the destination image ROI.
Figure “Bilinear Transform of an Image” gives an example of applying the bilinear warping function ippiWarpBilinear to a sample image.

**Bilinear Transform of an Image**

To estimate how the source image ROI will be transformed by the ippiWarpBilinear function, use functions ippiWarpBilinearQuad and ippiGetBilinearBound. To calculate coefficients of the bilinear transform which maps source ROI to a given quadrangle, use ippiGetBilinearTransform function.

Before using this function, compute the size of the external work buffer pBuffer using the WarpBilinearGetBufferSize function. Example shows how to use the ippiWarpBilinear_32f_C1R function.

**Return Values**

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error condition if one of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error condition if any image dimension has zero or negative value.</td>
</tr>
<tr>
<td>ippStsStepErr</td>
<td>Indicates an error condition if srcStep or dstStep has a zero or negative value.</td>
</tr>
</tbody>
</table>
WarpBilinearQuad MODIFIED API. Performs bilinear warping of the source image that transforms the given source quadrangle to the specified destination quadrangle.

GetBilinearBound Computes the bounding rectangle for the source ROI transformed by the ippiWarpBilinear function.

GetBilinearTransform Computes bilinear transform coefficients to map the source ROI to the quadrangle with the specified vertex coordinates.

WarpBilinearGetBufferSize Computes the size of the work buffer for bilinear warping.

**Syntax**

IppStatus ippiWarpBilinearBack_<mod>(const Ipp<datatype>* pSrc, IppiSize srcSize, int srcStep, IppiRect srcRoi, Ipp<datatype>* pDst, int dstStep, IppiRect dstRoi, const double coeffs[2][4], int interpolation, Ipp8u* pBuffer);

Supported values for mod:

- 8u_C1R
- 16u_C1R
- 32f_C1R
- 8u_C3R
- 16u_C3R
- 32f_C3R
- 8u_C4R
- 16u_C4R
- 32f_C4R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

pSrc
Pointer to the source image origin. An array of separate pointers to each plane in case of data in planar format.

srcSize
Size in pixels of the source image.

srcStep
Distance in bytes between starts of consecutive lines in the source image buffer.

srcRoi
Region of interest in the source image (of the IppiRect type).

pDst
Pointer to the destination image origin. An array of separate pointers to each plane in case of data in planar format.

dstStep
Distance in bytes between starts of consecutive lines in the destination image buffer.

dstRoi
Region of interest in the destination image (of the IppiRect type).

coeffs
The bilinear transform coefficients.

interpolation
Specifies the interpolation mode. Use one of the following values:

IPPI_INTER_NN Nearest neighbor interpolation
IPPI_INTER_LIN Linear interpolation
IPPI_INTER_CUB Cubic interpolation.

pBuffer
Pointer to the external work buffer.

Description

Important The API of this function has been modified in Intel IPP 9.0 release.

This function operates with ROI (see ROI Processing in Geometric Transforms).

This function performs the inverse transform to that defined by ippiWarpBilinear function. Pixel coordinates \( x' \) and \( y' \) in the transformed image are obtained from the following equations

\[
\begin{align*}
\alpha_{00} \cdot x' \cdot y' + \alpha_{01} \cdot x' + \alpha_{02} \cdot y' + \alpha_{03} &= x \\
\alpha_{10} \cdot x' \cdot y' + \alpha_{11} \cdot x' + \alpha_{12} \cdot y' + \alpha_{13} &= y
\end{align*}
\]

where \( x \) and \( y \) denote the pixel coordinates in the source image, and coefficients \( \alpha_{ij} \) are given in the array coeffs. Thus, you do not need to invert transform coefficients in your application program before calling ippiWarpBilinearBack.

Note that inverse transform functions handle source and destination ROI in a different way than other geometric transform functions. The implementation of the inverse transform functions has the following logic:

- Backward transform is applied to coordinates of each pixel in the destination ROI. The result is coordinates of some pixel in the source image.
- If the obtained source pixel is inside the source ROI, the corresponding pixel in the destination ROI is modified accordingly; otherwise, no changes are made.
Before using this function, compute the size of the external work buffer \( pBuffer \) using the \texttt{WarpBilinearGetBufferSize} function.

Example shows how to use the function \texttt{ippiWarpBilinearBack_32f_C1R}.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if any image dimension has zero or negative value.
- **ippStsStepErr**: Indicates an error condition if \( \text{srcStep} \) or \( \text{dstStep} \) has a zero or negative value.
- **ippStsInterpolationErr**: Indicates an error condition if \( \text{interpolation} \) has an illegal value.
- **ippStsCoeffErr**: Indicates an error condition if coefficient values are invalid.
- **ippStsWrongIntersectROIErr**: Indicates an error condition if \( \text{srcRoi} \) has no intersection with the source image.
- **ippStsWrongIntersectQuad**: Indicates a warning that no operation is performed if the transformed source ROI has no intersection with the destination ROI.

**See Also**

- Regions of Interest in Intel IPP
- WarpBilinear MODIFIED API. Performs bilinear warping of the source image using the specified transform coefficients.
- WarpBilinearGetBufferSize Computes the size of the work buffer for bilinear warping.

**WarpBilinearQuadGetBufferSize**

*Computes the size of the work buffer for bilinear warping of an arbitrary quadrangle in the source image ROI to the quadrangle in the destination image.*

**Syntax**

```c
IppStatus ippiWarpBilinearQuadGetBufferSize(IppSize srcSize, IppiRect srcRoi, const double srcQuad[4][2], IppiRect dstRoi, const double dstQuad[4][2], int interpolation, int* pBufSize);
```

**Include Files**

- ippi.h

**Domain Dependencies**

- Headers: ippcore.h, ippvm.h, ipps.h
- Libraries: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **srcSize**: Size of the source image, in pixels.
Source image ROI (of the *IppRect* type).

Quadrangle in the source image.

Destination image ROI (of the *IppRect* type).

Quadrangle in the destination image.

Interpolation mode. Supported values:

- **IPPI_INTER_NN**: Nearest neighbor interpolation
- **IPPI_INTER_LINEAR**: Linear interpolation
- **IPPI_INTER_CUBIC**: Cubic interpolation
- **IPPI_INTER_EDGE**: Use edge smoothing in addition to one of the above modes

Pointer to the size, in bytes, of the external buffer.

**Description**

This function computes the size of the external work buffer required for bilinear warping of an arbitrary quadrangle in the source image ROI to the quadrangle in the destination image. The result is stored in the `pBufSize` parameter.

**Return Values**

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error when `pBufSize` is NULL.
- **ippStsSizeErr**: Indicates an error:
  - If one of the ROI coordinates has a negative value.
  - If one of the ROI dimensions is less than, or equal to zero.
- **ippStsCoeffErr**: Indicates an error when bilinear transformation is singular.
- **ippStsInterpolationErr**: Indicates an error when `interpolation` has an illegal value.

**See Also**

`WarpBilinearQuad` MODIFIED API. Performs bilinear warping of the source image that transforms the given source quadrangle to the specified destination quadrangle.

**WarpBilinearQuad**

MODIFIED API. Performs bilinear warping of the source image that transforms the given source quadrangle to the specified destination quadrangle.

**Syntax**

```c
IppStatus ippiWarpBilinearQuad_<mod>(const Ipp<datatype>* pSrc, IppiSize srcSize, int srcStep, IppiRect srcRoi, const double srcQuad[4][2], Ipp<datatype>* pDst, int dstStep, IppiRect dstRoi, const double dstQuad[4][2], int interpolation, Ipp8u* pBuffer);
```

Supported values for `mod`:

- 8u_C1R
- 16u_C1R
- 32f_C1R
Include Files
ippi.h

Domain Dependencies
Headers: ippicore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pSrc

srcSize

srcStep

srcRoi

srcQuad

pDst

dstStep

dstRoi

dstQuad

interpolation

pBuffer

Description

Important The API of this function has been modified in Intel IPP 9.0 release.
This function operates with ROI (see ROI Processing in Geometric Transforms).

This function applies a bilinear transform to an arbitrary quadrangle `srcQuad` in the source image `pSrc`. The operations take place only in the intersection of the source image ROI `srcRoi` and the source quadrangle `srcQuad`. The function `ippiWarpBilinearQuad` uses the same formulas for pixel mapping as in the case of the `ippiWarpBilinear` function. Transform coefficients are computed internally, based on the mapping of the source quadrangle to the quadrangle `dstQuad` specified in the destination image `pDst`. The `dstQuad` should have a non-empty intersection with the destination image ROI `dstRoi`.


Edge smoothing interpolation is applicable only if the source quadrangle lies in the source image ROI.

Before using this function, compute the size of the external work buffer `pBuffer` using the `WarpBilinearGetBufferSize` function.

### Return Values

- **ippiStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.

- **ippiStsNullPtrErr**
  Indicates an error condition if one of the specified pointers is NULL.

- **ippiStsSizeErr**
  Indicates an error condition if any image dimension has zero or negative value.

- **ippiStsStepErr**
  Indicates an error condition if `srcStep` or `dstStep` has a zero or negative value.

- **ippiStsInterpolationErr**
  Indicates an error condition if `interpolation` has an illegal value.

- **ippiStsQuadErr**
  Indicates an error condition if `srcQuad` or `dstQuad` degenerates into triangle.

- **ippiStsWrongIntersectROIErr**
  Indicates an error condition if `srcRoi` has no intersection with the source image.

- **ippiStsWrongIntersectQuad**
  Indicates a warning that no operation is performed if the `srcRoi` has no intersection with the `srcQuad`, or `dstRoi` has no intersection with the `dstQuad`.

### See Also

- **Regions of Interest in Intel IPP**
- **WarpBilinear** MODIFIED API. Performs bilinear warping of the source image using the specified transform coefficients.
- **WarpBilinearGetBufferSize** Computes the size of the work buffer for bilinear warping.

### Mirror

**MIRRORS AN IMAGE ABOUT THE SPECIFIED AXIS (AXES).**
Syntax

Case 1: Not-in-place operation

IppStatus ippiMirror_<mod>(const Ippdatatype* pSrc, int srcStep, Ippdatatype* pDst, int dstStep, IppSize roiSize, IppiAxis flip);

Supported values for mod:

- 8u_C1R
- 16u_C1R
- 16s_C1R
- 32s_C1R
- 32f_C1R
- 8u_C3R
- 16u_C3R
- 16s_C3R
- 32s_C3R
- 32f_C3R
- 8u_C4R
- 16u_C4R
- 16s_C4R
- 32s_C4R
- 32f_C4R
- 8u_AC4R
- 16u_AC4R
- 16s_AC4R
- 32s_AC4R
- 32f_AC4R

Case 2: In-place operation

IppStatus ippiMirror_<mod>(Ippdatatype* pSrcDst, int srcDstStep, IppSize roiSize, IppiAxis flip);

Supported values for mod:

- 8u_C1IR
- 16u_C1IR
- 16s_C1IR
- 32s_C1IR
- 32f_C1IR
- 8u_C3IR
- 16u_C3IR
- 16s_C3IR
- 32s_C3IR
- 32f_C3IR
- 8u_C4IR
- 16u_C4IR
- 16s_C4IR
- 32s_C4IR
- 32f_C4IR
- 8u_AC4IR
- 16u_AC4IR
- 16s_AC4IR
- 32s_AC4IR
- 32f_AC4IR

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc

Pointer to the source buffer.

dstStep

Distance, in bytes, between the starting points of consecutive lines in the destination image buffer.

pDst

Pointer to the destination buffer.

srcStep

Distance, in bytes, between the starting points of consecutive lines in the source image buffer.

roiSize

IppSize

Parameter indicating the region of interest.

flip

IppiAxis

Axis of flip.

pSrcDst

Pointer to the source and destination buffer for the in-place operation.

dstStep

Distance, in bytes, between the starting points of consecutive lines in the source and destination image buffer for the in-place operation.
roiSize
flip

Size of the destination ROI in pixels.

Specifies the axis to mirror the image about. Use the following values to specify the axes:

ippAxsHorizontal for the horizontal axis.
ippAxsVertical for the vertical axis.
ippAxsBoth for both horizontal and vertical axes.
ippAxs45 for the 45-degree rotated axis.
ippAxs135 for the 135-degree rotated axis.

Description

TheippiMirror function operates with ROI (see Regions of Interest in Intel IPP). This function mirrors the source image pSrc about the axis (axes) specified by the value of the flip parameter and writes the result to the destination image pDst. Each function flavor can mirror an image about the horizontal or vertical axis or both.

TheippiMirror_8u_C1R,ippiMirror_16u_C1R,ippiMirror_16s_C1R, andippiMirror_32f_C1R function flavors can also use the ippAxs45 or ippAxs135 value of the flip parameter to mirror the source image about an axis rotated counterclockwise by 45 degrees or 135 degrees, respectively. For mirroring with each of these values of the flip parameter, the sizes of the source and destination ROI are different, and

\[
\text{roiSize.height} = \text{srcRoiSize.width} \\
\text{roiSize.width} = \text{srcRoiSize.height}
\]

Return Values

ippiStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippiStsNullPtrErr Indicates an error condition if one of the specified pointers is NULL.
ippiStsSizeErr Indicates an error condition if roiSize has a field with zero or negative value, or when one of the dimensions is equal to 1.
ippiStsMirrorFlipErr Indicates an error condition if flip has an illegal value.
ippiStsNotSupportedModeErr Indicates an error condition if intersection of the source and destination ROI is detected.
ippiStsStepErr Indicates an error condition if srcStep or dstStep has a zero or negative value or is not a multiple of the image data size (4 for floating-point images or 2 for short-integer images)

Examples

To better understand usage of theippiMirror function, refer to theMirror1.c andMirror2.c examples in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

Remap

Performs the look-up coordinate mapping of pixels of the source image.
Syntax

Case 1: Operation on pixel-order data

IppStatus ippiRemap_\_mod\>(const Ipp<datatype>* pSrc, IppSize srcSize, int srcStep, IppRect srcRoi, const Ipp32f* pxMap, int xMapStep, const Ipp32f* pyMap, int yMapStep, Ipp<datatype>* pDst, int dstStep, IppSize dstRoiSize, int interpolation);

Supported values for mod:

8u_C1R  16u_C1R  16s_C1R  32f_C1R
8u_C3R  16u_C3R  16s_C3R  32f_C3R
8u_C4R  16u_C4R  16s_C4R  32f_C4R
16u_AC4R  16s_AC4R  32f_AC4R

IppStatus ippiRemap_\_mod\>(const Ipp<datatype>* pSrc, IppSize srcSize, int srcStep, IppRect srcRoi, const Ipp64f* pxMap, int xMapStep, const Ipp64f* pyMap, int yMapStep, Ipp<datatype>* pDst, int dstStep, IppSize dstRoiSize, int interpolation);

Supported values for mod:

64f_C1R
64f_C3R
64f_C4R
64f_AC4R

IppStatus ippiRemap_8u_AC4R(const Ipp<datatype>* pSrc, IppSize srcSize, int srcStep, IppRect srcRoi, const Ipp32f* pxMap, int xMapStep, const Ipp32f* pyMap, int yMapStep, Ipp<datatype>* pDst, int dstStep, IppSize dstRoiSize, int interpolation);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc

Pointer to the source image origin. An array of separate pointers to each plane in case of data in planar format.

srcSize

Size, in pixels, of the source image.

dstSize

Distance, in bytes, between the starting points of consecutive lines in the source image buffer.

srcRoi

Region of interest in the source image (of the IppRect type).

pxMap, pyMap

Pointers to the starts of 2D buffers, containing tables of the x- and y- coordinates.
xMapStep, yMapStep

Steps, in bytes, through the buffers containing tables of the x- and y-coordinates.

pDst

Pointer to the destination image ROI. An array of separate pointers to ROI in each plane for planar image.

dstStep

Distance, in bytes, between the starting points of consecutive lines in the destination image buffer.

dstRoiSize

Size of the destination ROI in pixels.

interpolation

Specifies the interpolation mode. Possible values are:

IPPI_INTER_NN - nearest neighbor interpolation
IPPI_INTER_LINEAR - linear interpolation
IPPI_INTER_CUBIC - cubic interpolation
IPPI_INTER_LANCZOS - interpolation with Lanczos window
IPPI_INTER_CUBIC2P_CATMULLROM - Catmull-Rom spline

the following flag is used additionally to the above modes:

IPPI_SMOOTH_EDGE - edge smoothing

Description

This function operates with ROI (see ROI Processing in Geometric Transforms).

This function transforms the source image by remapping its pixels. Pixel remapping is performed using pxMap and pyMap buffers to look-up the coordinates of the source image pixel that is written to the target destination image pixel. The application has to supply these look-up tables. The remapping of the source pixels to the destination pixels is made according to the following formula:

\[
\text{dst}_\text{pixel}[i, j] = \text{src}_\text{pixel} [\text{pxMap}[i, j], \text{pyMap}[i, j]]
\]

where \(i, j\) are the x- and y-coordinates of the target destination image pixel \(\text{dst}_\text{pixel}\);

\(\text{pxMap}[i, j]\) contains the x- coordinates of the source image pixels \(\text{src}_\text{pixel}\) that are written to \(\text{dst}_\text{pixel}\);

\(\text{pyMap}[i, j]\) contains the y- coordinates of the source image pixels \(\text{src}_\text{pixel}\) that are written to \(\text{dst}_\text{pixel}\).

If the referenced coordinates correspond to a pixel outside of the source ROI, and the flag IPPI_SMOOTH_EDGE is not set, then no mapping of the source pixel is performed.
Figure “Remapping the Sample Image” gives an example of applying the function `ippiRemap` to a sample image that is a square grid of alternating blue, red, and green lines.

**Remapping the Sample Image**

![Sample Image](image)

The transformed part of the image is resampled using the interpolation method specified by the `interpolation` parameter, and is written to the destination image ROI. The function can be used with or without edge smoothing. The pseudo code below shows how it works.

The function works without edge smoothing - the flag `IPPI_SMOOTH_EDGE` is not set:

```c
if (xMap < srcRoi.x || xMap > srcRoi.x + srcRoi.width -1 || yMap < srcRoi.y ||
    yMap > srcRoi.y + srcRoi.height -1)
    not fill dst /* do not remap */
else
    fill dst with Interpolate(Src, xMap, yMap) /* remap */
```

The function works with edge smoothing - the flag `IPPI_SMOOTH_EDGE` is set:

```c
if (xMap < srcRoi.x - 1 || xMap > srcRoi.x+srcRoi.width || yMap < srcRoi.y - 1 || yMap >
    srcRoi.y+srcRoi.height)
    not fill dst /* do not remap */
else if (xMap < srcRoi.x || xMap > srcRoi.x+srcRoi.width-1 || yMap < srcRoi.y || yMap >
    srcRoi.y+srcRoi.height-1)
    fill dst with Interpolate(Src, fillvalue, xMap, yMap) /* smoothing */
else
    fill dst with Interpolate(Src, xMap, yMap) /* remap */
```

**Return Values**

- `ippStsNoErr` Indicates no error. Any other value indicates an error or a warning.
ippsStsNullPtrErr

Indicates an error condition if one of the specified pointers is NULL.

ippsStsSizeErr

Indicates an error condition if srcSize or dstRoiSize has a field with zero or negative value.

ippsStsStepErr

Indicates an error condition if one of the srcStep, dstStep, xMapStep, or yMapStep has a zero or negative value.

ippsStsInterpolationErr

Indicates an error condition if interpolation has an illegal value.

ippsStsWrongIntersectROIErr

Indicates an error condition if srcRoi has no intersection with the source image.

**Example**

To better understand usage of the ippiRemap function, refer to the Remap.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.
This section describes the Intel® IPP image processing functions that perform adaptive thresholding of the image ROI.

### ThresholdAdaptiveBoxGetBufferSize

*Computes the size of the work buffer for adaptive thresholding with the Box method.*

#### Syntax

```c
IppStatus ippiThresholdAdaptiveBoxGetBufferSize(IppiSize roiSize, IppiSize maskSize, IppDataType dataType, int numChannels, int* pBufferSize);
```

#### Include Files

ippi.h

#### Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

#### Parameters

- **roiSize**: Size of the destination image ROI, in pixels.
- **maskSize**: Size of the kernel that is used to calculate a threshold level. Width and height of `maskSize` must be equal and odd.
- **dataType**: Data type of the source and destination images. Possible value is ipp8u.
- **numChannels**: Number of channels in the images. Possible value is 1.
- **pBufferSize**: Pointer to the size, in bytes, of the external work buffer.

#### Description

This function computes the size, in bytes, of the external work buffer needed for the `ThresholdAdaptiveBox` function. The result is stored in `pBufferSize`.

For an example on how to use this function, refer to the example provided with the `ThresholdAdaptiveBox` function description.

#### Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error.
- **ippStsNullPtrErr**: Indicates an error when `pBufferSize` is NULL.
- **ippStsSizeErr**: Indicates an error when `roiSize` has a field with a zero or negative value.
- **ippStsMaskSizeErr**: Indicates an error when `maskSize` has a field with a zero or negative value, or fields of `maskSize` are not equal.
**ippStsDataTypeErr** Indicates an error when `dataType` has an illegal value.

**ippStsNumChannelsErr** Indicates an error when `numChannels` has an illegal value.

**See Also**

**ThresholdAdaptiveBox** Performs adaptive thresholding with the Box method.

## ThresholdAdaptiveBox

**Performs adaptive thresholding with the Box method.**

### Syntax

```c
IppStatus ippiThresholdAdaptiveBox_8u_C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, IppiSize maskSize, Ipp32f delta, Ipp8u valGT, Ipp8u valLE, IppiBorderType borderType, Ipp8u borderValue, Ipp8u* pBuffer);
```

```c
IppStatus ippiThresholdAdaptiveBox_8u_C1IR(Ipp8u* pSrcDst, int srcDstStep, IppiSize roiSize, IppiSize maskSize, Ipp32f delta, Ipp8u valGT, Ipp8u valLE, IppiBorderType borderType, Ipp8u borderValue, Ipp8u* pBuffer);
```

### Include Files

`ippi.h`

### Domain Dependencies

**Headers:** `ippcore.h`, `ippvm.h`, `ipps.h`

**Libraries:** `ippcore.lib`, `ippvm.lib`, `ipps.lib`

### Parameters

- **pSrc**
  - Pointer to the source image ROI.

- **srcStep**
  - Distance, in bytes, between the starting points of consecutive lines in the source image.

- **pDst**
  - Pointer to the destination image ROI.

- **dstStep**
  - Distance, in bytes, between the starting points of consecutive lines in the destination image.

- **pSrcDst**
  - Pointer to the source and destination image ROI (for the in-place function).

- **srcDstStep**
  - Distance, in bytes, between the starting points of consecutive lines in the source and destination image (for the in-place function).

- **roiSize**
  - Size of the destination image ROI, in pixels.

- **maskSize**
  - Size of the kernel that is used to calculate a threshold level. Width and height of `maskSize` must be equal and odd.

- **delta**
  - Value for threshold calculation.

- **valGT**
  - Output pixel if the source pixel value is more than threshold.

- **valLE**
  - Output pixel if the source pixel value is less than, or equal to threshold.

- **borderType**
  - Type of border. Possible values are:
Values of all border pixels are set to a constant.

Border is replicated from the edge pixels.

Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderRepl or ippBorderConst and the following flags:

- ippBorderInMemTop
- ippBorderInMemBottom
- ippBorderInMemLeft
- ippBorderInMemRight

Each of these flags means that for the corresponding border the outside pixels of the source image are in memory.

**borderValue**

Constant value(s) to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

**pBuffer**

Pointer to the work buffer. To calculate the size of the temporary buffer, use the ThresholdAdaptiveBoxGetBufferSize function.

**Description**

This function performs adaptive thresholding of the source image ROI using the Box method. Output pixels are calculated according to the following formulas:

\[
\begin{align*}
    p_{Dst}(x,y) &= \text{valGT}, \text{ if } p_{Src}(x,y) > T(x,y) \\
    p_{Dst}(x,y) &= \text{valLE}, \text{ if } p_{Src}(x,y) \leq T(x,y)
\end{align*}
\]

where

\(T(x,y)\) is a mean of the \(maskSize.width \times maskSize.height\) neighborhood of a \((x, y)\) pixel minus \(delta\).

Before using this function, compute the size of the external work buffer using the ThresholdAdaptiveBoxGetBufferSize function.

**Return Values**

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error when \(p_{Src}, p_{Dst}, p_{SrcDst},\) or \(p_{Buffer}\) is NULL.
- ippStsSizeErr: Indicates an error when \(roiSize\) has a field with a zero or negative value.
- ippStsMaskSizeErr: Indicates an error when \(maskSize\) has a field with a zero or negative value, or fields of \(maskSize\) are not equal.
- ippStsBorderErr: Indicates an error when \(borderType\) has an illegal value.
Example

The code example below demonstrates how to use the `ippiThresholdAdaptiveBox_8u_C1R` and `ThresholdAdaptiveBoxGetBufferSize` functions.

```c
IppStatus threshold_adaptive_box_8u_c1( void ) {
    Ipp8u pSrc[8*8] = {
        0, 255,   1, 254,   2, 253,   3, 252,
        251,   4, 250,   5, 249,   6, 248,   7,
        8, 247,   9, 246,  10, 245,  11, 244,
        243, 12 , 242, 13, 241, 14, 240, 15,
        16, 239, 17, 238, 18, 237, 19, 236,
        235, 20, 234, 21, 233, 22, 232, 23,
        24, 231, 25, 230, 26, 229, 26, 228,
        227, 27, 226, 28, 225, 29, 224, 30
    };
    Ipp8u    pDst[8*8];
    IppiSize roiSize = {8, 8};
    IppiSize maskSize = {3, 3};
    IppiBorderType borderType = ippBorderConst;
    int     srcStep = 8 * sizeof(Ipp8u);
    int     dstStep = 8 * sizeof(Ipp8u);
    int     bufferSize;
    IppStatus status;
    Ipp32f  delta = 0.5f;
    Ipp8u   valGT = 254;
    Ipp8u   valLE = 1;
    Ipp8u   *pBuffer;

   ippiThresholdAdaptiveBoxGetBufferSize(roiSize, maskSize, ipp8u, 1, &bufferSize);
    pBuffer = ippsMalloc_8u(bufferSize);
    ippiThresholdAdaptiveBox_8u_C1R(pSrc, srcStep, pDst, dstStep, roiSize, maskSize, delta,
    valGT, valLE, borderType, 33, pBuffer);
    ippsFree(pBuffer);
    return status;
}

pDst after function execution:

1 254 1 254 1 254 1 254
254 1 254 1 254 1 254 1
1 254 1 254 1 254 1 254
254 1 254 1 254 1 254 1
1 254 1 254 1 254 1 254
254 1 254 1 254 1 254 1
1 254 1 254 1 254 1 254
254 1 254 1 254 1 254 1

See Also

ThresholdAdaptiveBoxGetBufferSize Computes the size of the work buffer for adaptive thresholding with the Box method.

ThresholdAdaptiveGaussGetBufferSize

Computes the size of the adaptive threshold specification structure and the size of the work buffer for adaptive thresholding with the Gaussian method.
Syntax

IppStatus ippiThresholdAdaptiveGaussGetBufferSize(IppSize roiSize, IppSize maskSize, IppDataType dataType, int numChannels, int* pSpecSize, int* pBufferSize);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

roiSize         Size of the destination image ROI, in pixels.
maskSize        Size of the kernel that is used to calculate a threshold level. Width and height of maskSize must be equal and odd.
dataType        Data type of the source and destination images. Possible value is ipp8u.
numChannels     Number of channels in the images. Possible value is 1.
pSpecSize       Pointer to the size of the adaptive threshold specification structure.
pBufferSize     Pointer to the size (in bytes) of the external work buffer.

Description

This function computes the size, in bytes, of the adaptive threshold specification structure and the size of the external work buffer needed for the ThresholdAdaptiveGauss function. The results are stored in pSpecSize and pBufferSize.

For an example on how to use this function, refer to the example provided with the ThresholdAdaptiveGauss function description.

Return Values

ippStsNoErr      Indicates no error. Any other value indicates an error.
ippStsNullPtrErr Indicates an error when pSpecSize or pBufferSize is NULL.
ippStsSizeErr    Indicates an error when roiSize has a field with a zero or negative value.
ippStsMaskSizeErr Indicates an error when maskSize has a field with a zero or negative value, or fields of maskSize are not equal.
ippStsDataTypeErr Indicates an error when dataType has an illegal value.
ippStsNumChannelsErr Indicates an error when numChannels has an illegal value.

See Also

ThresholdAdaptiveGauss  Performs adaptive thresholding with the Gaussian method.
ThresholdAdaptiveGaussInit

Initializes the threshold adaptive specification structure for adaptive thresholding with the Gaussian method.

Syntax

IppStatus ippiThresholdAdaptiveGaussInit(IppiSize roiSize, IppiSize maskSize, IppDataType dataType, int numChannels, Ipp32f sigma, IppiThresholdAdaptiveSpec* pSpec);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>roiSize</td>
<td>Size of the destination image ROI, in pixels.</td>
</tr>
<tr>
<td>maskSize</td>
<td>Size of the kernel that is used to calculate a threshold value. Width and</td>
</tr>
<tr>
<td></td>
<td>height of maskSize must be equal and odd.</td>
</tr>
<tr>
<td>dataType</td>
<td>Data type of the source and destination images. Possible value is ipp8u.</td>
</tr>
<tr>
<td>numChannels</td>
<td>Number of channels in the images. Possible value is 1.</td>
</tr>
<tr>
<td>sigma</td>
<td>Value of sigma that is used to calculate a threshold value for the Gaussian</td>
</tr>
<tr>
<td></td>
<td>method. If sigma value is less than, or equal to zero, sigma is set</td>
</tr>
<tr>
<td></td>
<td>automatically in compliance with the kernel size.</td>
</tr>
<tr>
<td>pSpec</td>
<td>Pointer to the adaptive threshold specification structure.</td>
</tr>
</tbody>
</table>

Description

This function initializes the adaptive threshold specification structure pSpec for adaptive thresholding with the Gaussian method. Before using this function, compute the size of the specification structure using the ThresholdAdaptiveGaussGetBufferSize function.

If sigma is less than, or equal to zero, it is set according to the following formula:

\[
\text{sigma} = 0.3 \times ((\text{maskSize}.\text{width} - 1) \times 0.5 - 1) + 0.8
\]

For an example on how to use this function, refer to the example provided with the ThresholdAdaptiveGauss function description.

Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error when pSpecSize is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error when dstRoiSize has a field with a zero or negative value.</td>
</tr>
<tr>
<td>ippStsMaskSizeErr</td>
<td>Indicates an error when maskSize has a field with a zero or negative value, or fields of maskSize are not equal.</td>
</tr>
</tbody>
</table>
ippStsDataTypeErr Indicates an error when dataType has an illegal value.

ippStsNumChannelsErr Indicates an error when numChannels has an illegal value.

See Also
ThresholdAdaptiveGaussGetBufferSize Computes the size of the adaptive threshold specification structure and the size of the work buffer for adaptive thresholding with the Gaussian method.

ThresholdAdaptiveGauss Performs adaptive thresholding with the Gaussian method.

**ThresholdAdaptiveGauss**

Performs adaptive thresholding with the Gaussian method.

**Syntax**

```c
IppStatus ippiThresholdAdaptiveGauss_8u_C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, Ipp32f delta, Ipp8u valGT, Ipp8u valLE, IppiBorderType borderType, Ipp8u borderValue, IppiThresholdAdaptiveSpec* pSpec, Ipp8u* pBuffer);

IppStatus ippiThresholdAdaptiveGauss_8u_C1IR(Ipp8u* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp32f delta, Ipp8u valGT, Ipp8u valLE, IppiBorderType borderType, Ipp8u borderValue, IppiThresholdAdaptiveSpec* pSpec, Ipp8u* pBuffer);
```

**Include Files**

`ippi.h`

**Domain Dependencies**

**Headers:** `ippcore.h`, `ippvm.h`, `ipps.h`

**Libraries:** `ippcore.lib`, `ippvm.lib`, `ipps.lib`

**Parameters**

- **pSrc**
  - Pointer to the source image ROI.
- **srcStep**
  - Distance, in bytes, between the starting points of consecutive lines in the source image.
- **pDst**
  - Pointer to the destination image ROI.
- **dstStep**
  - Distance, in bytes, between the starting points of consecutive lines in the destination image.
- **pSrcDst**
  - Pointer to the source and destination image ROI (for the in-place function).
- **srcDstStep**
  - Distance, in bytes, between the starting points of consecutive lines in the source and destination image (for the in-place function).
- **roiSize**
  - Size of the destination image ROI, in pixels.
- **delta**
  - Value for threshold calculation.
- **valGT**
  - Output pixel if the source pixel value is more than threshold.
- **valLE**
  - Output pixel if the source pixel value is less than, or equal to threshold.
**borderType**

Type of border. Possible values are:

- ippBorderConst: Values of all border pixels are set to a constant.
- ippBorderRepl: Border is replicated from the edge pixels.
- ippBorderInMem: Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderRepl or ippBorderConst and the following flags:

- ippBorderInMemTop
- ippBorderInMemBottom
- ippBorderInMemLeft
- ippBorderInMemRight

Each of these flags means that for the corresponding border the outside pixels of the source image are in memory.

**borderValue**

Constant value(s) to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

**pSpec**

Pointer to the adaptive threshold specification structure.

**pBuffer**

Pointer to the work buffer. To calculate the size of the temporary buffer, use the ThresholdAdaptiveGaussGetBufferSize function.

**Description**

This function performs adaptive thresholding of the source image ROI using the Gaussian method. Output pixels are calculated according to the following formulas:

\[
\begin{align*}
\text{pDst}(x,y) &= \text{valGT} \quad \text{if} \quad \text{pSrc}(x,y) > T(x,y) \\
\text{pDst}(x,y) &= \text{valLE} \quad \text{if} \quad \text{pSrc}(x,y) \leq T(x,y)
\end{align*}
\]

where

\[
T(x,y) \text{ is a weighted sum (cross-correlation with a Gaussian window) of the maskSize.width*maskSize.height neighborhood of a } (x, y) \text{ pixel minus } \delta.
\]

The function uses a separable Gaussian filter. Filter coefficients are computed according to the following formula:

\[
G_i = A \cdot \exp\left(-i\cdot\frac{\text{maskSize.width}-1}{2}\right) / (0.5 \cdot \sigma^2)
\]

where

\[
A \text{ is a scale factor for } \sum G_i = 1 \quad (i = 0, ..., \text{maskSize.width}-1)
\]

Before using this function, compute the size of the external work buffer and specification structure using the ThresholdAdaptiveGaussGetBufferSize function, and initialize the structure using the ThresholdAdaptiveGaussInit function.

**Return Values**

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error when pSrc, pDst, pSrcDst, pSpec, or pBuffer is NULL.
**Example**

The code example below demonstrates how to use the `ippiThresholdAdaptiveGauss_8u_C1R`, `ThresholdAdaptiveGaussGetBufferSize`, and `ThresholdAdaptiveGaussInit` functions.

```c
IppStatus threshold_adaptive_gauss_8u_c1( void ) {
    Ipp8u pSrc[8*8] =
    {
        0, 255,   1, 254,   2, 253,   3, 252,
        251,  4, 250,   5, 249,   6, 248,   7,
        8, 247,  9, 246,  10, 245,  11, 244,
        243, 12 , 242, 13, 241,  14, 240,  15,
        16, 239,  17, 238,  18, 237,  19, 236,
        235, 20, 234,  21, 233,  22, 232,  23,
        24, 231,  25, 230,  26, 229,  26, 228,
        227, 27, 226,  28, 225,  29, 224,  30
    };
    Ipp8u   pDst[8*8];
    IppiSize roiSize = {8, 8};
    IppiSize maskSize = {3, 3};
    IppiBorderType borderType = ippBorderConst;
    int     srcStep = 8 * sizeof(Ipp8u);
    int     dstStep = 8 * sizeof(Ipp8u);
    int     bufferSize;
    int     specSize;
    IppStatus status;
    Ipp32f  sigma = 10.0f;
    Ipp32f  delta = 0.5f;
    Ipp8u   valGT = 254;
    Ipp8u   valLE = 1;
    IppiThresholdAdaptiveSpec *pSpec;
    Ipp8u   *pBuffer;

    ippiThresholdAdaptiveGaussGetBufferSize(roiSize, maskSize, ipp8u, 1, &specSize, &bufferSize);
    pSpec = (IppiThresholdAdaptiveSpec *)ippsMalloc_8u(specSize);
    pBuffer = ippsMalloc_8u(bufferSize);
    ippiThresholdAdaptiveGaussInit(roiSize, maskSize, ipp8u, 1, sigma, pSpec);
    ippiThresholdAdaptiveGauss_8u_C1R(pSrc, srcStep, pDst, dstStep, roiSize, delta, valGT, valLE, borderType, 33, pSpec, pBuffer);
    ippsFree(pBuffer);
    ippsFree(pSpec);

    return status;
}
```

*pDst after function execution:*

<table>
<thead>
<tr>
<th>1 254</th>
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</tbody>
</table>
ThresholdAdaptiveGaussGetBufferSize  Computes the size of the adaptive threshold specification structure and the size of the work buffer for adaptive thresholding with the Gaussian method.

ThresholdAdaptiveGaussInit  Initializes the threshold adaptive specification structure for adaptive thresholding with the Gaussian method.
Wavelet Transforms

This chapter describes the Intel® IPP image processing functions that perform two-dimensional discrete wavelet transform (DWT).

In many applications the multiresolution analysis by discrete wavelet transforms is a better alternative to windowing and discrete Fourier analysis techniques. On the one hand, the forward two-dimensional wavelet transform may be considered as a decomposition of an image on the base of functions bounded or localized in space; and on the other, the wavelet transforms are related to subband filtering and resampling.

Intel IPP for image processing contains one-level discrete wavelet decomposition and reconstruction functions. It also provides the necessary interface for initialization and deallocation of the transform context structure.

The wavelet transform type can be set by specifying the appropriate filter taps in the initialization function. Note that Intel IPP supports only one-dimensional finite impulse response filters for separable convolution.

The Intel IPP functions for wavelet decomposition and reconstruction use fast polyphase algorithm, which is equivalent to traditional application of separable convolution and dyadic resampling in different order. Figure “Equivalent Scheme of Wavelet Decomposition Algorithm” shows the equivalent algorithm of wavelet-based image decomposition:

Equivalent Scheme of Wavelet Decomposition Algorithm

Decomposition operation applied to a source image produces four output images of equal size: approximation image, horizontal detail image, vertical detail image, and diagonal detail image.
These decomposition components have the following meaning:

- The ‘approximation’ image is obtained by vertical and horizontal lowpass filtering.
- The ‘horizontal detail’ image is obtained by vertical highpass and horizontal lowpass filtering.
- The ‘vertical detail’ image is obtained by vertical lowpass and horizontal highpass filtering.
- The ‘diagonal detail’ image is obtained by vertical and horizontal highpass filtering.

The above image names are used in this document for identification convenience only.

The wavelet-based image reconstruction can be represented by a sequence of separate convolution and dyadic upsampling.

The reconstruction function uses four input images that are the same as those resulting from the decomposition operation.

Figure “Equivalent Scheme of Wavelet Reconstruction Algorithm” shows the equivalent algorithm of wavelet reconstruction of an image.
Wavelet transform functions support regions of interest (ROI, see Regions of Interest in Intel IPP in chapter 2) in the images. However, these functions do not perform internally any border extensions of image ROI data. It means that source images must already contain all border data that are necessary for convolution operations. See descriptions of the functions ippiWTFwd and ippiWTInv for detailed information on how to calculate extended image border sizes.

**Equivalent Scheme of Wavelet Reconstruction Algorithm**

---

**WTFwdGetSize**

*Calculates the size of the specification structure and work buffer for a forward wavelet transform.*
Syntax
IppStatus ippiWTFwdGetSize_32f(int numChannels, int lenLow, int anchorLow, int lenHigh, int anchorHigh, int* pSpecSize, int* pBufSize);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
numChannels  Number of channels in the image. Possible values are 1 or 3.
lenLow       Length of the lowpass filter.
anchorLow    Anchor position of the lowpass filter.
lenHigh      Length of the highpass filter.
anchorHigh   Anchor position of the highpass filter.
pSpecSize    Pointer to the computed size of the ippiWTFwd specification structure, in bytes.
pBufSize     Pointer to the computed size of the work buffer, in bytes.

Description
This function computes the size, in bytes, of the specification structure and work buffer required for the forward wavelet transform function ippiWTFwd.

For an example on how to use this function, refer to the example provided with the ippiWTInv function description.

Return Values
ippStsNoErr     Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error when any of the specified pointers is NULL.
ippStsNumChannlesErr Indicates an error when numChannels has an illegal value.
ippStsNumChannlesErr Indicates an error when lenLow or lenHigh is less than 2.
ippStsAnchorErr  Indicates an error when anchorLow or anchorHigh is less than zero.

See Also
WTFwd  Performs one-level wavelet decomposition of an image.
WTInv  Performs one-level wavelet reconstruction of an image.

WTFwdInit
Initializes the forward wavelet transform context structure.
Syntax

IppStatus ippiWTFwdInit_32f_C1R(IppiWTFwdSpec_32f_C1R* pSpec, const Ipp32f* pTapsLow, int lenLow, int anchorLow, const Ipp32f* pTapsHigh, int lenHigh, int anchorHigh);
IppStatus ippiWTFwdInit_32f_C3R(IppiWTFwdSpec_32f_C3R* pSpec, const Ipp32f* pTapsLow, int lenLow, int anchorLow, const Ipp32f* pTapsHigh, int lenHigh, int anchorHigh);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSpec  
Double pointer to the forward wavelet transform specification structure.

pTapsLow  
Pointer to lowpass filter taps.

lenLow  
Length of the lowpass filter.

anchorLow  
Anchor position of the lowpass filter.

pTapsHigh  
Pointer to highpass filter taps.

lenHigh  
Length of the highpass filter.

anchorHigh  
Anchor position of the highpass filter.

Description

This function initializes the specification structure *pSpec* for a one-level wavelet decomposition.

The forward wavelet transform specification structure contains parameters of a wavelet filter bank used for image decomposition. The filter bank consists of two analysis filters and includes the lowpass decomposition filter (or coarse filter) and the highpass decomposition filter (or detail filter).

The parameters *pTapsLow* and *pTapsHigh* specify coefficients, and *anchorLow* and *anchorHigh* - anchor positions for two synthesis filters. The anchor value sets the initial leftmost filter position relative to image row or column as shown in the figure below:

Anchor Value and Initial Filter Position for Wavelet Decomposition

![Anchor Value and Initial Filter Position for Wavelet Decomposition](image-url)
Here $a$ stands for anchor value, $N$ is filter length, $x_0$ is the starting pixel of the processed row or column, and $x-1, x-2, ...$ are the additional border pixels that are needed for calculations. The anchor value and filter length determine right, left, top, and bottom border sizes for the source image used in decomposition. The corresponding C-language expressions to calculate border sizes are given in the description of ippiWTFwd function.

For an example on how to use this function, refer to the example provided with the ippiWTInv function description.

**Return Values**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error or a warning.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error when any of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsNumChannelsErr</td>
<td>Indicates an error when <code>numChannels</code> has an illegal value.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error when filter length <code>lenLow</code> or <code>lenHigh</code> is less than 2.</td>
</tr>
<tr>
<td>ippStsAnchorErr</td>
<td>Indicates an error when anchor position <code>anchorLow</code> or <code>anchorHigh</code> is less than zero.</td>
</tr>
</tbody>
</table>

**See Also**

- **WTFwdGetSize** Calculates the size of the specification structure and work buffer for a forward wavelet transform.
- **WTInv** Performs one-level wavelet reconstruction of an image.
- **WTFwd** Performs one-level wavelet decomposition of an image.

**WTInv**

Performs one-level wavelet decomposition of an image.

**Syntax**

```c
IppStatus ippiWTFwd_32f_C1R (const Ipp32f* pSrc, int srcStep, Ipp32f* pApproxDst, int approxStep, Ipp32f* pDetailXDst, int detailXStep, Ipp32f* pDetailYDst, int detailYStep, Ipp32f* pDetailXYDst, int detailXYStep, IppiSize dstRoiSize, const IppiWTFwdSpec_32f_C1R* pSpec, Ipp8u* pBuffer);
IppStatus ippiWTFwd_32f_C3R (const Ipp32f* pSrc, int srcStep, Ipp32f* pApproxDst, int approxStep, Ipp32f* pDetailXDst, int detailXStep, Ipp32f* pDetailYDst, int detailYStep, Ipp32f* pDetailXYDst, int detailXYStep, IppiSize dstRoiSize, const IppiWTFwdSpec_32f_C3R* pSpec, Ipp8u* pBuffer);
```

**Include Files**

ippi.h

**Parameters**

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance, in bytes, between the starting points of consecutive lines in the source image buffer.
- **pApproxDst**: Pointer to ROI of the destination approximation image.
**approxStep**
Distance, in bytes, between the starting points of consecutive lines in the approximation image buffer.

**pDetailXDst**
Pointer to ROI of the destination horizontal detail image.

**detailXStep**
Distance, in bytes, between the starting points of consecutive lines in the horizontal detail image buffer.

**pDetailYDst**
Pointer to ROI of the destination vertical detail image.

**detailYStep**
Distance, in bytes, between the starting points of consecutive lines in the vertical detail image buffer.

**pDetailXYDst**
Pointer to ROI of the destination diagonal detail image.

**detailXYStep**
Distance, in bytes, between the starting points of consecutive lines in the diagonal detail image buffer.

**dstRoiSize**
Size of the ROI in pixels for all destination images.

**pSpec**
Pointer to the allocated and initialized forward DWT specification structure.

**pBuffer**
Pointer to the allocated buffer for intermediate operations.

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP). This function performs one-level wavelet decomposition of a source image pointed to by **pSrc** into four destination subimages pointed to by **pApproxDst**, **pDetailXDst**, **pDetailYDst**, and **pDetailXYDst**. See Figure “Equivalent Scheme of Wavelet Decomposition Algorithm” for the equivalent algorithm of **ippiWTFwd** function operation.

Wavelet parameters are contained in the forward transform specification structure **pSpec**. Before using this function, compute the size of the structure and work buffer using the **WTFwdGetSize** function and initialize the structure using **WTFwdInit**.

**Optimization Notice**
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Notice revision #20110804

The pointer **pSrc** points to memory location of the source image rectangular ROI of size **srcWidth** by **srcHeight** which is uniquely determined by the size of destination ROI as:

```
srcWidth = 2 * dstRoiSize.width
srcHeight = 2 * dstRoiSize.height
```

The source image ROI size always has even dimensions, as it is computed from the **dstRoiSize** parameter as follows:

```
srcRoiSize.width = 2 * dstRoiSize.width
srcRoiSize.height = 2 * dstRoiSize.height
```
To use this function for images with uneven width or height, you should truncate the last column/row or extend an image to even dimensions.

**NOTE**
The source image ROI does not include border pixels necessary to compute some destination pixels. It means that prior to using ippiWTFwd function the application program must apply some border extension model (symmetrical, wraparound or another) to the source image ROI through filling of neighboring memory locations. As a result, the size of memory block allocated for the source image must be extended to accommodate for added border pixels outside ROI formal boundaries.

Figure "Extended Source Image for Wavelet Decomposition" schematically shows the source image ROI and extended image area.

Extended Source Image for Wavelet Decomposition

Use the following C-language expressions to calculate extended image border sizes:

```c
int leftBorderLow = lenLow - 1 - anchorLow;
int leftBorderHigh = lenHigh - 1 - anchorHigh;
int rightBorderLow = anchorLow;
int rightBorderHigh = anchorHigh;
int leftTopBorder = IPP_MAX(leftBorderLow, leftBorderHigh);
int rightBottomBorder = IPP_MAX(rightBorderLow, rightBorderHigh);
```

See the description of the function WTFwdInit for the explanation of the parameters.

Note that the left and top borders have equal size. The same holds for the right and bottom borders which have equal size too.

The size of the source image area extended by border pixels can be defined as

```c
srcWidthWithBorders = srcWidth + leftTopBorder + rightBottomBorder;
srcHeightWithBorders = srcHeight + leftTopBorder + rightBottomBorder;
```
All destination images have equal size specified by the parameter \texttt{dstRoiSize}.

Conversely, to perform a wavelet reconstruction of the full size source image from the component images obtained by decomposition, use extended component images for the reconstruction pass. See the description of the function \texttt{ippiWTInv} for more details.

The ROI concept used in wavelet transform functions can be applied to processing large images by blocks, or 'tiles'. To accomplish this, the source image should be subdivided into overlapping blocks in the following way:

- Main part (ROI) of each block is adjacent to neighboring blocks and has no intersection with neighbor's ROIs;
- Extended borders of each block overlap with ROIs of neighboring blocks.

This subdivision scheme is illustrated in Figure "Image Division into Blocks with Overlapping Borders".

**Image Division into Blocks with Overlapping Borders**

For an example on how to use this function, refer to the example provided with the \texttt{WTInv} function description.

**Return Values**

- \texttt{ippStsNoErr} Indicates no error. Any other value indicates an error or a warning.
- \texttt{ippStsNullPtrErr} Indicates an error condition if any of the specified pointers is NULL.
- \texttt{ippStsSizeErr} Indicates an error condition if \texttt{dstRoiSize} has a field with zero or negative value.
- \texttt{ippStsStepErr} Indicates an error condition if step through any buffer is less than or equal to zero.
- \texttt{ippStsContextMatchErr} Indicates an error condition if a pointer to an invalid specification structure is passed.

**See Also**

- \texttt{WTFwdGetSize} Calculates the size of the specification structure and work buffer for a forward wavelet transform.
- \texttt{WTFwdInit} Initializes the forward wavelet transform context structure.
- \texttt{WTInv} Performs one-level wavelet reconstruction of an image.
WTFwdGetSize

Calculates the size of the specification structure and work buffer for an inverse wavelet transform.

Syntax

IppStatus ippiWTInvGetSize_32f(int numChannels, int lenLow, int anchorLow, int lenHigh, int anchorHigh, int* pSpecSize, int* pBufSize);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- numChannels: Number of channels in the image. Possible values are 1 or 3.
- lenLow: Length of the lowpass filter.
- anchorLow: Anchor position of the lowpass filter.
- lenHigh: Length of the highpass filter.
- anchorHigh: Anchor position of the highpass filter.
- pSpecSize: Pointer to the computed size of the ippiWTInv specification structure, in bytes.
- pBufSize: Pointer to the computed size of the work buffer, in bytes.

Description

This function computes the size, in bytes, of the specification structure and work buffer required for the inverse wavelet transform function ippiWTInv.

For an example on how to use this function, refer to the example provided with the ippiWTInv function description.

Return Values

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error when any of the specified pointers is NULL.
- ippStsNumChannlesErr: Indicates an error when numChannels has an illegal value.
- ippStsNumChannlesErr: Indicates an error when lenLow or lenHigh is less than 2.
- ippStsAnchorErr: Indicates an error when anchorLow or anchorHigh is less than zero.

See Also

WTInv  Performs one-level wavelet reconstruction of an image.
WTInvInit

Initializes the inverse wavelet transform specification structure.

Syntax

IppStatus ippiWTInvInit_32f_C1R (IppiWTInvSpec_32f_C1R* pSpec, const Ipp32f* pTapsLow, int lenLow, int anchorLow, const Ipp32f* pTapsHigh, int lenHigh, int anchorHigh);

IppStatus ippiWTInvInit_32f_C3R (IppiWTInvSpec_32f_C3R* pSpec, const Ipp32f* pTapsLow, int lenLow, int anchorLow, const Ipp32f* pTapsHigh, int lenHigh, int anchorHigh);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSpec  
Double pointer to a new allocated and initialized inverse DWT context structure.

pTapsLow  
Pointer to lowpass filter taps.

lenLow  
Length of the lowpass filter.

anchorLow  
Anchor position of the lowpass filter.

pTapsHigh  
Pointer to highpass filter taps.

lenHigh  
Length of the highpass filter.

anchorHigh  
Anchor position of the highpass filter.

Description

This function initializes the specification structure pSpec for a one-level wavelet reconstruction.

The inverse wavelet transform specification structure contains parameters of a wavelet filter bank used for image reconstruction. The filter bank consists of two synthesis filters and includes the lowpass reconstruction filter (or coarse filter) and the highpass reconstruction filter (or detail filter).
The parameters \( pTapsLow \) and \( pTapsHigh \) specify coefficients, and \( anchorLow \) and \( anchorHigh \) - anchor positions for two synthesis filters. The anchor value sets the initial leftmost filter position relative to image row or column as shown in the figure below:

**Anchor Value and Initial Filter Position for Wavelet Reconstruction**

![Anchor position diagram](image)

Here \( a \) stands for anchor value, \( N \) is filter length, \( x0 \) is the starting pixel of the processed row or column, and \( x-1, x-2,... \) are the additional border pixels that are needed for calculations. As seen from this figure, anchor position is specified relative to upsampled source data. The anchor value and filter length completely determine right, left, top, and bottom border sizes for source images used in reconstruction. The corresponding C-language expressions to calculate border sizes are given in the description of the \( ippWTInv \) function.

For an example on how to use this function, refer to the example provided with the \( ippiWTInv \) function description.

### Return Values

- **ippStsNoErr**
  - Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**
  - Indicates an error when any of the specified pointers is **NULL**.

- **ippStsNumChannelsErr**
  - Indicates an error when \( numChannels \) has an illegal value.

- **ippStsSizeErr**
  - Indicates an error when filter length \( lenLow \) or \( lenHigh \) is less than 2.

- **ippStsAnchorErr**
  - Indicates an error when anchor position \( anchorLow \) or \( anchorHigh \) is less than zero.

### See Also

- **WTInvGetSize** Calculates the size of the specification structure and work buffer for an inverse wavelet transform.
- **WTInv** Performs one-level wavelet reconstruction of an image.

### WTInv

*Performs one-level wavelet reconstruction of an image.*
Syntax

IppStatusippiWTInv_32f_C1R(const Ipp32f* pApproxSrc, int approxStep, const Ipp32f* pDetailXSrc, int detailXStep, const Ipp32f* pDetailYSrc, int detailYStep, const Ipp32f* pDetailXYSrc, int detailXYStep, IppiSize srcRoiSize, Ipp32f* pDst, int dstStep, const IppiWTInvSpec_32f_C1R* pSpec, Ipp8u* pBuffer);

IppStatusippiWTInv_32f_C3R(const Ipp32f* pApproxSrc, int approxStep, const Ipp32f* pDetailXSrc, int detailXStep, const Ipp32f* pDetailYSrc, int detailYStep, const Ipp32f* pDetailXYSrc, int detailXYStep, IppiSize srcRoiSize, Ipp32f* pDst, int dstStep, const IppiWTInvSpec_32f_C3R* pSpec, Ipp8u* pBuffer);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pApproxSrc Pointer to ROI of the source approximation image.
approxStep Distance, in bytes, between the starting points of consecutive lines in the approximation image buffer.
pDetailXSrc Pointer to ROI of the source horizontal detail image.
detailXStep Distance, in bytes, between the starting points of consecutive lines in the horizontal detail image buffer.
pDetailYSrc Pointer to ROI of the source vertical detail image.
detailYStep Distance, in bytes, between the starting points of consecutive lines in the vertical detail image buffer.
pDetailXYSrc Pointer to ROI of the source diagonal detail image.
detailXYStep Distance, in bytes, between the starting points of consecutive lines in the diagonal detail image buffer.
srcRoiSize Size of ROI in pixels for all source images.
pDst Pointer to the destination image ROI.
dstStep Distance, in bytes, between the starting points of consecutive lines in the destination image buffer.
pSpec Pointer to the allocated and initialized inverse DWT specification structure.
pBuffer Pointer to the allocated buffer for intermediate operations.

Description

This function operates with ROI (see Regions of Interest in Intel IPP). This function performs wavelet reconstruction of the output image pDst from the four component images. See Figure “Image Division into Blocks with Overlapping Borders” for the equivalent algorithm ofippiWTInv function operation. Wavelet parameters are contained in the inverse transform specification structure pSpec. Before using this function, compute the size of the structure and work buffer using theippiWTInvGetSize function and initialize the structure usingippiWTInvInit.
The pointers \textit{pApproxSrc}, \textit{pDetailXSrc}, \textit{pDetailYSrc}, and \textit{pDetailXYSrc} point to ROIs of source images excluding borders. All source ROIs have the same size \textit{srcRoiSize}, while the destination image size is uniquely determined from the following relations:

\[
\text{dstWidth} = 2 \times \text{srcRoiSize.width}; \quad \text{dstHeight} = 2 \times \text{srcRoiSize.height};
\]

As source ROIs do not include border pixels required to computations, the application program have to apply a border extension model (symmetrical, wraparound or another) to ROIs of all source images filling the neighboring memory locations. Note the border sizes may be different for different source images. The following C-language expressions can be used to calculate extended image border sizes:

\begin{verbatim}
int leftBorderLow    = (lenLow - 1 - anchorLow) / 2;
int leftBorderHigh   = (lenHigh - 1 - anchorHigh) / 2;
int rightBorderLow   = (anchorLow + 1) / 2;
int rightBorderHigh  = (anchorHigh + 1) / 2;
int apprLeftBorder   = leftBorderLow;
int apprRightBorder  = rightBorderLow;
int apprTopBorder    = leftBorderLow;
int apprBottomBorder = rightBorderLow;
int detxLeftBorder   = leftBorderLow;
int detxRightBorder  = rightBorderLow;
int detxTopBorder    = leftBorderHigh;
int detxBottomBorder = rightBorderHigh;
int detyLeftBorder   = leftBorderHigh;
int detyRightBorder  = rightBorderHigh;
int detyTopBorder    = leftBorderLow;
int detyBottomBorder = rightBorderLow;
int detxyLeftBorder  = leftBorderHigh;
int detxyRightBorder = rightBorderHigh;
int detxyTopBorder   = leftBorderHigh;
int detxyBottomBorder = rightBorderHigh;
\end{verbatim}

See the description of the function \texttt{ippiWTInvInit} for the explanation of the used parameters.

The above relations show that left and top borders always have equal size only for approximation and diagonal detail images. Right and bottom borders also have equal size only for approximation and diagonal detail images. Thus, the size of memory block allocated for each source image must be extended to accommodate for added border pixels outside ROI.
Figure “Extended Horizontal Detail Source Image for Wavelet Reconstruction” shows ROI and extended image area for the horizontal detail source image.

Extended Horizontal Detail Source Image for Wavelet Reconstruction

Sizes of source images extended by border pixels can be calculated as follows:

- \( \text{apprWidthWithBorders} = \text{srcWidth} + \text{apprLeftBorder} + \text{apprRightBorder}; \)
- \( \text{apprHeightWithBorders} = \text{srcHeight} + \text{apprTopBorder} + \text{apprBottomBorder}; \)
- \( \text{detxWidthWithBorders} = \text{srcWidth} + \text{detxLeftBorder} + \text{detxRightBorder}; \)
- \( \text{detxHeightWithBorders} = \text{srcHeight} + \text{detxTopBorder} + \text{detxBottomBorder}; \)
- \( \text{detyWidthWithBorders} = \text{srcWidth} + \text{detyLeftBorder} + \text{detyRightBorder}; \)
- \( \text{detyHeightWithBorders} = \text{srcHeight} + \text{detyTopBorder} + \text{detyBottomBorder}; \)
- \( \text{detxyWidthWithBorders} = \text{srcWidth} + \text{detxyLeftBorder} + \text{detxyRightBorder}; \)
- \( \text{detxyHeightWithBorders} = \text{srcHeight} + \text{detxyTopBorder} + \text{detxyBottomBorder}; \)

The ROI concept can be used to reconstruct large images by blocks or 'tiles'. To accomplish this, each the source images into blocks with overlapping borders, similar to what is considered in the description of the function ippiWTFwd. Each component must be subdivided into the same pattern of rectangular blocks.

Return Values

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error condition if any of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error condition if srcRoiSize has a field with zero or negative value.
- ippStsStepErr: Indicates an error condition if step through any buffer is less than or equal to zero.
- ippStsContextMatchErr: Indicates an error condition if a pointer to an invalid specification structure is passed.
The example below shows how to use the function `ippiWTInv_32f_C1R`.

```c
void func_wavelet()
{
    IppiWTFwdSpec_32f_C1R* pSpecFwd;
    IppiWTInvSpec_32f_C1R* pSpecInv;
    int specSizeFwd, specSizeInv;
    Ipp32f pTapsLow[3] = {0.25, 0.5, 0.25};
    int lenLow = 3;
    int anchorLow = 1;
    Ipp32f pTapsHigh[3] = { 0.75, -0.25, -0.125};
    int lenHigh = 3;
    int anchorHigh = 1;
    Ipp32f pSrc[8*8] = { 0.0,  0.0,  0.0, 11.1, 11.1,  0.0,  0.0,  0.0,
                        0.0,  0.0,  0.0, 11.1, 11.1,  0.0,  0.0,  0.0,
                        0.0,  0.0,  0.0, 11.1, 11.1,  0.0,  0.0,  0.0,
                        11.1, 11.1, 11.1, 11.1, 11.1, 11.1, 11.1, 11.1,
                        11.1, 11.1, 11.1, 11.1, 11.1, 11.1, 11.1, 11.1,
                        0.0,  0.0,  0.0, 11.1, 11.1,  0.0,  0.0,  0.0,
                        0.0,  0.0,  0.0, 11.1, 11.1,  0.0,  0.0,  0.0,
                        0.0,  0.0,  0.0, 11.1, 11.1,  0.0,  0.0,  0.0};
    int srcStepB = 9*sizeof(Ipp32f);
    IppSize roiSizeB = {9, 9};
    int srcStep = 8*sizeof(Ipp32f);
    IppSize roiSize = {8, 8};
    Ipp32f pDetailXDst[4*4];
    Ipp32f pDetailYDst[4*4];
    Ipp32f pDetailXYDst[4*4];
    Ipp32f pApproxDst[4*4];
    IppSize dstRoiSize = {4, 4};
    int bufSizeFwd, bufSizeInv;
    Ipp8u* pBufferFwd;
    Ipp8u* pBufferInv;
    Ipp32f pSrcB[9*9];
    Ipp32f pSrc[8*8];
    IppSize roiInvSize = {4, 4};
    IppSize roiInvSizeB = {5, 5};
    int stepDstInv = 8*sizeof(Ipp32f);
    int approxStep, detailXStep, detailYStep, detailXYStep;
    approxStep = detailXStep = detailYStep = detailXYStep = 4*sizeof(Ipp32f);
    // addslashes to the source image
    ippiCopyWrapBorder_32s_C1R((Ipp32s*)pSrc, srcStep, roiSize, (Ipp32s*)pSrcB, srcStepB, roiSizeB, 1, 1);
    ippiWTFwdGetSize_32f(1, lenLow, anchorLow, lenHigh, anchorHigh, &specSizeFwd, &bufSizeFwd);
    pSpecFwd = (IppiWTFwdSpec_32f_C1R*)ippMalloc(specSizeFwd);
    pBufferFwd = (Ipp8u*)ippMalloc(bufSizeFwd);
    ippiWTFwdInit_32f_C1R( pSpecFwd, pTapsLow, lenLow, anchorLow, pTapsHigh, lenHigh, anchorHigh);
    ippiWTFwd_32f_C1R (pSrcB + roiSizeB.width + 1, srcStepB, pApproxDst, approxStep,
                      pDetailXDst, detailXStep, pDetailYDst, detailYStep, pDetailXYDst, detailXYStep,
                      dstRoiSize, pSpecFwd, pBufferFwd);
```
```c
printf_32f_2D("After WTFwd ->\n pApproxDst", pApproxDst, dstRoiSize, approxStep, ippStsNoErr);
printf_32f_2D("pDetailXDst", pDetailXDst, dstRoiSize, detailXStep, ippStsNoErr);
printf_32f_2D("pDetailYDst", pDetailYDst, dstRoiSize, detailYStep, ippStsNoErr);
printf_32f_2D("pDetailXYDst", pDetailXYDst, dstRoiSize, detailXYStep, ippStsNoErr);

//------------------------------------
ippiWTInvGetSize_32f(1, lenLow, anchorLow, lenHigh, anchorHigh, &specSizeInv, &bufSizeInv);
pSpecInv = (IppiWTInvSpec_32f_C1R*)ippMalloc(specSizeInv);
pBufferInv = (Ipp8u*)ippMalloc(bufSizeInv);
ippiWTInvInit_32f_C1R(pSpecInv, pTapsLow, lenLow, anchorLow, pTapsHigh, lenHigh, anchorHigh);
//adds border to four images obtained after ippiWTFwd
ippiCopyWrapBorder_32s_C1R((Ipp32s*)pApproxDst, approxStep, dstRoiSize, (Ipp32s*)pAppB, StepB, roiInvSizeB, 0, 0);
ippiCopyWrapBorder_32s_C1R((Ipp32s*)pDetailXDst, detailXStep, dstRoiSize, (Ipp32s*)pXB, StepB, roiInvSizeB, 0, 0);
ippiCopyWrapBorder_32s_C1R((Ipp32s*)pDetailYDst, detailYStep, dstRoiSize, (Ipp32s*)pYB, StepB, roiInvSizeB, 0, 0);
ippiCopyWrapBorder_32s_C1R((Ipp32s*)pDetailXYDst, detailXYStep, dstRoiSize, (Ipp32s*)pXYB, StepB, roiInvSizeB, 0, 0);
//performs inverse wavelet transform
ippiWTInv_32f_C1R( pAppB, StepB, pXB, StepB, pYB, StepB, pXYB, StepB, roiInvSize, pDstInv, stepDstInv, pSpecInv, pBufferInv);

printf_32f_2D("After WTFinv ->\n pDstInv", pDstInv, roiSize, stepDstInv, ippStsNoErr);
ippFree(pSpecFwd);
ippFree(pSpecInv);
ippFree(pBufferFwd);
ippFree(pBufferInv);
}
```

Result:

After WTFwd ->
pApproxDst
0.0 2.8  8.3  0.0
 2.8 4.9  9.0  2.8
 8.3 9.0 10.4  8.3
0.0 2.8  8.3  0.0
pDetailXDst
 0.0 1.0  3.1  0.0
 8.3 7.3  5.2  8.3
-4.2 -2.1  2.1  -4.2
 0.0 1.0  3.1  0.0
pDetailYDst
 0.0 8.3  -4.2  0.0
 1.0 7.3  -2.1  1.0
 3.1 5.2   2.1  3.1
 0.0 8.3  -4.2  0.0
pDetailXYDst
 0.0 3.1  -1.6  0.0
 3.1 0.0   4.7  3.1
-1.6  4.7  -4.7  -1.6
 0.0 3.1  -1.6  0.0
After WTFinv ->
pDstInv
 0.0 2.8 -0.3  -0.6  2.1  1.1  0.0  0.0
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<tr>
<td>1.1</td>
<td>5.4</td>
<td>0.7</td>
<td>1.2</td>
<td>3.7</td>
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<td>1.1</td>
<td>1.9</td>
</tr>
<tr>
<td>0.0</td>
<td>2.8</td>
<td>-0.3</td>
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<td>2.1</td>
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<tr>
<td>0.0</td>
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<td>3.8</td>
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**See Also**

- **WTInvGetSize**  Calculates the size of the specification structure and work buffer for an inverse wavelet transform.
- **WTInvInit**  Initializes the inverse wavelet transform specification structure.
- **WTFwd**  Performs one-level wavelet decomposition of an image.
This chapter provides some background for the computer vision concepts used in the Intel® IPP library as well as detailed descriptions of the Intel IPP image processing functions for computer vision. These functions are combined in groups by their functionality.

UsingippiAddforBackgroundDifferencing

This section describes functions that help build a statistical model of a background. This model can be used to subtract the background from an image.

Here, the term “background” stands for a set of motionless image pixels—that is, pixels that do not belong to any object, moving in front of the camera. The definition of background can vary if considered in other techniques of object extraction. For example, if the depth map of the scene can be obtained, for example, with the help of stereo, background can be determined as static parts of the scene that are located far enough from the camera.

The simplest background model assumes that every background pixel brightness varies independently, according to normal distribution. To calculate the characteristics of the background, several dozens of frames, as well as their squares, can be accumulated. That is, for every pixel location we find the sum of pixel values in this location $S(x, y)$, using the function ippiAdd, and the sum of squares of the values $Sq(x, y)$, using the function ippiAddSquare. Then mean is calculated as

$$m(x, y) = \frac{S(x, y)}{N},$$

where $N$ is the number of collected frames, and standard deviation as

$$stddev(x, y) = \sqrt{\frac{Sq(x, y)}{N} - \left(\frac{S(x, y)}{N}\right)^2}$$

After that, the pixel in a certain pixel location within a certain frame is considered as belonging to a moving object, if the condition $abs(p(x, y) - m(x, y)) < C \times stddev(x, y)$, where $C$ is a constant, is met. If $C$ is equal to 3, it satisfies the “three sigmas” rule. To obtain such background model, objects should be put away from the camera for a few seconds, so that the whole image from the camera represents the subsequent background observation.

Adapting the background differencing model to changes in lighting conditions and background scenes, for example, when the camera moves or an object passes behind the front object, can improve the described technique.

The mean brightness can be calculated through replacing the simple average with the running average found by using the function ippiAddWeighted. Also, several techniques can be used to identify moving scene parts and exclude them while accumulating background information. These techniques include change detection (see the functions ippiAbsDiff in chapter 5 and ippiThreshold in chapter 7), optical flow, and some other operations.

Relevant addition functions used for background differencing include:

Add_8u32f_C1IR, Add_8s32f_C1IR, Add_32f_C1IR,
Add_8u32f_C1IMR, Add_8s32f_C1IMR, Add_32f_C1IMR (see Add),
and also all flavors of AddSquare, AddProduct, and AddWeighted.

Feature Detection Functions

This section describes feature detection functions.
The set of the Sobel derivative filters is generally used to find edges, ridges, and blobs, especially in case of scale-space images, for example, pyramids.

The following naming conventions are used in the equations described below:
- $D_x$ and $D_y$ are the first $x$ and $y$ derivatives, respectively.
- $D_{xx}$ and $D_{yy}$ are the second $x$ and $y$ derivatives, respectively.
- $D_{xy}$ is the partial $x$ and $y$ derivative.
- $D_{xxx}$ and $D_{yyy}$ are the third $x$ and $y$ derivatives, respectively.
- $D_{xxy}$ and $D_{xyy}$ are the third partial $x$ and $y$ derivatives.

**Corner Detection**

The Sobel and Scharr first derivative operators are to be used to take the $x$ and $y$ derivatives of an image. Then a small region of interest (ROI) is to be defined to detect corners in.

A 2x2 matrix of sums of the $x$ and $y$ derivatives is created as follows:

$$ A = \sum_{u} \sum_{v} w(u, v) \begin{bmatrix} I_x^2 & I_x I_y \\ I_x I_y & I_y^2 \end{bmatrix} = \begin{bmatrix} \langle I_x^2 \rangle & \langle I_x I_y \rangle \\ \langle I_x I_y \rangle & \langle I_y^2 \rangle \end{bmatrix} $$

Solving

$$ \det(C - \lambda I) = 0 $$

where $\lambda$ is a column vector of the eigen values and $I$ is the identity matrix, gives the eigen values. For the 2x2 matrix of the equation above, the solutions may be written in a closed form:

$$ \lambda = \frac{\Sigma D_x^2 + \Sigma D_y^2 \pm \sqrt{(\Sigma D_x^2 + \Sigma D_y^2)^2 - 4 \cdot (\Sigma D_x^2 \Sigma D_y^2 - (\Sigma D_x D_y)^2)}}{2} $$

If $\lambda_1, \lambda_2 > \tau$, where $\tau$ is some threshold, then a corner is considered to be found at that location. This can be very useful for object or shape recognition.

**FastNGetSize**

*Computes the size of the FastN context structure.*

**Syntax**

```c
IppStatus ippiFastNGetSize(IppSize srcSize, int circleRadius, int N, int orientationBins, int option, IppDataType dataType, int numChannels, int* pSpecSize);
```

**Include Files**

ippcv.h

**Domain Dependencies**

*Headers:* ippcore.h, ippvm.h, ipps.h,ippi.h

*Libraries:* ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- `srcSize` Size of the source ROI, in pixels.
circleRadius

Radius of the pixel circle. The radius value equal to 1 corresponds to the distance between the closest pixels from common row or column. Supported values are 1, 2, 3, 5, 7, 9.

N

Critical number of serial pixels on circle for defining a corner. The ranges are as follows:

<table>
<thead>
<tr>
<th>circleRadius</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5 ≤ N ≤ 8</td>
</tr>
<tr>
<td>2</td>
<td>7 ≤ N ≤ 12</td>
</tr>
<tr>
<td>3</td>
<td>9 ≤ N ≤ 16</td>
</tr>
<tr>
<td>5</td>
<td>15 ≤ N ≤ 28</td>
</tr>
<tr>
<td>7</td>
<td>21 ≤ N ≤ 40</td>
</tr>
<tr>
<td>9</td>
<td>27 ≤ N ≤ 52</td>
</tr>
</tbody>
</table>

orientationBins

The number of bins to define direction. Supported values are from 2 to 64.

option

Mode of processing. Supported values:

- IPP_FASTN_CIRCLE
- (IPP_FASTN_CIRCLE | IPP_FASTN_ORIENTATION)
- (IPP_FASTN_CIRCLE | IPP_FASTN_SCORE_MODE0)
- (IPP_FASTN_CIRCLE | IPP_FASTN_ORIENTATION | IPP_FASTN_SCORE_MODE0)
- (IPP_FASTN_CIRCLE | IPP_FASTN_SCORE_MODE0 | IPP_FASTN_NMS)
- (IPP_FASTN_CIRCLE | IPP_FASTN_ORIENTATION | IPP_FASTN_SCORE_MODE0 | IPP_FASTN_NMS)

dataType

Data type of the source and destination images. Supported value is ipp8u.

numChannels

Number of channels in the images. Supported value is 1.

pSpecSize

Pointer to the computed size of the specification structure.

Description

This function computes the size of the FastN context structure for the FastN function. The result is stored in pSpecSize.

Use the computed pSpecSize value to allocate memory using the ippMalloc or ippsMalloc functions. The allocated memory can be freed only by the ippFree or ippsFree functions, respectively. For more information about the memory allocation functions, refer to the Support Functions section of the Intel IPP Developer Reference, vol. 1.

For an example on how to use this function, refer to the example provided with the FastN function description.

Return Values

- ippStsNoErr: Indicates no error. Any other value indicates an error.
- ippStsNullPtrErr: Indicates an error when pSpecSize is NULL.
- ippStsSizeErr: Indicates an error when srcSize is less than, or equal to zero.
- ippDataTypeErr: Indicates an error when dataType has an illegal value.
- ippNumChannelsErr: Indicates an error when numChannels has an illegal value.
ippOutOfRangeErr Indicates an error when orientationBins or N has an illegal value.
ippBadArgErr Indicates an error when option or circleRadius has an illegal value.

See Also
FastN Detects corners in an image using the FastN algorithm.

FastNGetBufferSize
Computes the size of the work buffer for the FastN function.

Syntax
IppStatus ippiFastNGetBufferSize(IppiFastNSpec* pSpec, IppiSize dstRoiSize, int* pBufSize);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
pSpec Pointer to the FastN specification structure.
dstRoiSize Size of the destination ROI, in pixels.
pBufSize Pointer to the computed size of the work buffer.

Description
This function computes the size of the work buffer for the FastN function. The result is stored in pBufSize. Use the computed pBufSize value to allocate memory using the ippMalloc or ippsMalloc functions. The allocated memory can be freed only by the ippFree or ippsFree functions, respectively. For more information about the memory allocation functions, refer to the Support Functions section of the Intel IPP Developer Reference, vol. 1.
For an example on how to use this function, refer to the example provided with the FastN function description.

Return Values
ippStsNoErr Indicates no error. Any other value indicates an error.
ippStsNullPtrErr Indicates an error when pSpecSize or pBufSize is NULL.
ippStsSizeErr Indicates an error when dstRoiSize is less than, or equal to zero.

See Also
FastN Detects corners in an image using the FastN algorithm.
**FastNInit**

*Initializes the FastN context structure.*

**Syntax**

```c
IppStatus ippiFastNInit(IppiSize srcSize, int circleRadius, int N, int orientationBins, int option, Ipp32f threshold, IppDataType dataType, int numChannels, IppiFastNSpec* pSpec);
```

**Include Files**

ippcv.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

**Parameters**

- `srcSize` - Size of the source ROI, in pixels.
- `circleRadius` - Radius of the pixel circle. The radius value equal to 1 corresponds to the distance between the closest pixels from common row or column. Supported values are 1, 2, 3, 5, 7, 9.
- `N` - Critical number of serial pixels on circle for defining a corner. The ranges are as follows:

<table>
<thead>
<tr>
<th>circleRadius</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5 ≤ N ≤ 8</td>
</tr>
<tr>
<td>2</td>
<td>7 ≤ N ≤ 12</td>
</tr>
<tr>
<td>3</td>
<td>9 ≤ N ≤ 16</td>
</tr>
<tr>
<td>5</td>
<td>15 ≤ N ≤ 28</td>
</tr>
<tr>
<td>7</td>
<td>21 ≤ N ≤ 40</td>
</tr>
<tr>
<td>9</td>
<td>27 ≤ N ≤ 52</td>
</tr>
</tbody>
</table>

- `orientationBins` - The number of bins to define direction. Supported values are from 2 to 64.
- `option` - Mode of processing. Supported values:
  - IPP_FASTN_CIRCLE
  - (IPP_FASTN_CIRCLE | IPP_FASTN_ORIENTATION)
  - (IPP_FASTN_CIRCLE | IPP_FASTN_SCORE_MODE0)
  - (IPP_FASTN_CIRCLE | IPP_FASTN_ORIENTATION | IPP_FASTN_SCORE_MODE0)
  - (IPP_FASTN_CIRCLE | IPP_FASTN_SCORE_MODE0 | IPP_FASTN_NMS)
  - (IPP_FASTN_CIRCLE | IPP_FASTN_ORIENTATION | IPP_FASTN_SCORE_MODE0 | IPP_FASTN_NMS)

- `threshold` - Threshold value to detect critical pixels. The value must be more than, or equal to zero.
- `dataType` - Data type of the source and destination images. Supported value is ipp8u.
- `numChannels` - Number of channels in the images. Supported value is 1.
pSpec

Pointer to the specification structure.

Description
This function initializes the FastN context structure for the FastN function.
For an example on how to use this function, refer to the example provided with the FastN function description.

Return Values
<table>
<thead>
<tr>
<th>Enum</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error when pSpec is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error when srcSize is less than, or equal to zero.</td>
</tr>
<tr>
<td>ippDataTypeErr</td>
<td>Indicates an error when dataType has an illegal value.</td>
</tr>
<tr>
<td>ippNumChannelsErr</td>
<td>Indicates an error when numChannels has an illegal value.</td>
</tr>
<tr>
<td>ippOutOfRangeErr</td>
<td>Indicates an error when orientationBins or N has an illegal value.</td>
</tr>
<tr>
<td>ippBadArgErr</td>
<td>Indicates an error when option or circleRadius has an illegal value.</td>
</tr>
<tr>
<td>ippThresholdErr</td>
<td>Indicates an error when threshold is negative.</td>
</tr>
</tbody>
</table>

See Also
FastN
Detects corners in an image using the FastN algorithm.

FastN
Detects corners in an image using the FastN algorithm.

Syntax
IppStatus ippiFastN_8u_C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDstCorner, int dstCornerStep, Ipp8u* pDstScore, int dstScoreStep, int* pNumCorner, IppiPoint srcRoiOffset, IppiSize dstRoiSize, IppiFastNSpec* pSpec, Ipp8u* pBuffer);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipp.h, ipp.h
Libraries: ippcore.lib, ippvm.lib, ipp.lib,ippi.lib

Parameters
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pSrc</td>
<td>Pointer to the source image.</td>
</tr>
<tr>
<td>srcStep</td>
<td>Distance, in bytes, between the starting points of consecutive lines in the source image.</td>
</tr>
<tr>
<td>pDstCorner</td>
<td>Pointer to the destination image with corners.</td>
</tr>
</tbody>
</table>
**Description**

The `ippiFastN` function implements the FastN corner detection algorithm. This function detects corners in the source image, calculates orientation and score of corners.

The figures below show pixels location for different radius values.

**Radius = 1**

<table>
<thead>
<tr>
<th>Px3</th>
<th>Px4</th>
<th>Px5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Px2</td>
<td>pxc</td>
<td>Px6</td>
</tr>
<tr>
<td>Px1</td>
<td>Px0</td>
<td>Px7</td>
</tr>
</tbody>
</table>

**Radius = 2**

```
+---+---+---+---+
|   | Px5| Px6| Px7 |
+---+---+---+---+
| Px4|    |    | Px8 |
| Px3| pxc|    | Px9 |
| Px2|    |    | Px10|
| Px1| Px0| Px11|
```

**Radius = 3**

<table>
<thead>
<tr>
<th>Px3</th>
<th>Px4</th>
<th>Px5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Px2</td>
<td></td>
<td>Px6</td>
</tr>
<tr>
<td>Px1</td>
<td>pxc</td>
<td>Px7</td>
</tr>
<tr>
<td>Px0</td>
<td></td>
<td>Px8</td>
</tr>
<tr>
<td>Px11</td>
<td></td>
<td>Px9</td>
</tr>
<tr>
<td>Px10</td>
<td></td>
<td>Px11</td>
</tr>
</tbody>
</table>

- `dstCornerStep` - Distance, in bytes, between the starting points of consecutive lines in the destination image with corners.
- `pDstScore` - Pointer to the destination image with scores.
- `dstScoreStep` - Distance, in bytes, between the starting points of consecutive lines in the destination image with scores.
- `pNumCorner` - Pointer to the calculated number of corners.
- `srcRoiOffset` - Offset in the source image.
- `dstRoiSize` - Size of the destination ROI, in pixels.
- `pSpec` - Pointer to the specification structure.
- `pBuffer` - Pointer to the work buffer.
### Radius = 5

<table>
<thead>
<tr>
<th></th>
<th>Px7</th>
<th>Px8</th>
<th>Px9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Px6</td>
<td></td>
<td></td>
<td>Px10</td>
</tr>
<tr>
<td>Px5</td>
<td></td>
<td>Px11</td>
<td></td>
</tr>
<tr>
<td>Px4</td>
<td>pxc</td>
<td></td>
<td>Px12</td>
</tr>
<tr>
<td>Px3</td>
<td></td>
<td></td>
<td>Px13</td>
</tr>
<tr>
<td>Px2</td>
<td></td>
<td></td>
<td>Px14</td>
</tr>
<tr>
<td>Px1</td>
<td>Px0</td>
<td></td>
<td>Px15</td>
</tr>
</tbody>
</table>

### Radius = 7

<table>
<thead>
<tr>
<th></th>
<th>Px12</th>
<th>Px13</th>
<th>Px14</th>
<th>Px15</th>
<th>Px16</th>
</tr>
</thead>
<tbody>
<tr>
<td>Px11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Px17</td>
</tr>
<tr>
<td>Px10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Px18</td>
</tr>
<tr>
<td>Px9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Px19</td>
</tr>
<tr>
<td>Px8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Px20</td>
</tr>
<tr>
<td>Px7</td>
<td>pxc</td>
<td></td>
<td></td>
<td></td>
<td>Px21</td>
</tr>
<tr>
<td>Px6</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Px22</td>
</tr>
<tr>
<td>Px5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Px23</td>
</tr>
<tr>
<td>Px4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Px24</td>
</tr>
<tr>
<td>Px3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Px25</td>
</tr>
<tr>
<td>Px2</td>
<td>Px1</td>
<td>Px0</td>
<td></td>
<td>Px27</td>
<td>Px26</td>
</tr>
</tbody>
</table>
The function defines a pixel as a corner if the value of $N$ consecutive pixels located on the circle with the center at the current pixel is greater (less) than the value of the current - central pixel. Differences between the values of pixels on the circle and the central pixel value must be greater than the threshold value. In this case, the corresponding pixel of the $pDstCorner$ image is set to the following values in binary format:

- If greater - 01xxxxxx
- If less - 10xxxxxx

If the IPP_FASTN_ORIENTATION mode is not set, xxxxxx = 000000, otherwise, xxxxxx = the number of sector (bin) to which the corner directs. The orientationBin parameter defines the number of sectors that is computed from the bottom clockwise. If the source pixel is not a corner, the corresponding pixel of $pDstCorner$ is set to zero.
If the IPP_FASTN_SCORE_MODE0 mode is set, the corresponding pixel of \textit{pDstCorner} is set to the corner score. Score is a maximum among minimal differences with \textit{threshold} calculated for every \textit{N} consecutive pixels. If the source pixel is not a corner, the corresponding pixel of \textit{pDstScore} is set to zero.

If the IPP_FASTN_NMS mode is set, the corners that have a corner with the greater score among neighboring pixels are cancelled.

\textbf{Return Values}

- \textit{ippStsNoErr} Indicates no error. Any other value indicates an error.
- \textit{ippStsNullPtrErr} Indicates an error when:
  - \textit{pSrc}, \textit{pDstCorner}, \textit{pNumCorner}, \textit{pSpec}, or \textit{pBuffer} is NULL
  - \textit{pDstScore} is NULL if \textit{option} is not equal to IPP_FASTN_SCORE_MODE0
- \textit{ippStsSizeErr} Indicates an error when \textit{dstRoiSize} is less than, or equal to zero.
- \textit{ippDataTypeErr} Indicates an error when \textit{dataType} has an illegal value.
- \textit{ippNumChannelsErr} Indicates an error when \textit{numChannels} has an illegal value.
- \textit{ippOutOfRangeErr} Indicates an error when \textit{orientationBins} or \textit{N} has an illegal value.
- \textit{ippBadArgsErr} Indicates an error when \textit{option} or \textit{circleRadius} has an illegal value.
- \textit{ippThresholdErr} Indicates an error when \textit{threshold} is negative.

\textbf{Example}

To better understand usage of the \textit{ippiFastN} function, refer to the \textit{FastN.c} example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

\textbf{See Also}

- \textit{FastNGetSize} Computes the size of the FastN context structure.
- \textit{FastNInit} Initializes the FastN context structure.
- \textit{FastNGetBufferSize} Computes the size of the work buffer for the \textit{FastN} function.
- \textit{FastN2DToVec} Converts corners from two-dimensional image to an array of structures.

\textbf{FastN2DToVec}

Converts corners from two-dimensional image to an array of structures.

\textbf{Syntax}

\begin{verbatim}
IppStatus ippiFastN2DToVec_8u(const Ipp8u* pSrcCorner, int srcCornerStep, const Ipp8u* pSrcScore, int srcScoreStep, IppiCornerFastN* pDst, IppiSize srcRoiSize, int maxLen, int* pNumCorners, IppiFastNSpec* pSpec);
\end{verbatim}

\textbf{Include Files}

ippcv.h

\textbf{Domain Dependencies}

- Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
- Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Parameters

pSrcCorner         Pointer to the source image with corners.
srcCornerStep     Distance, in bytes, between the starting points of consecutive lines in the source image with corners.
pSrcScore         Pointer to the source image with scores.
srcScoreStep      Distance, in bytes, between the starting points of consecutive lines in the source image with score.
pDst              Pointer to the destination vector of structures.
srcRoiSize        Size of the source ROI, in pixels.
maxLen            Length of the array of structures.
pNumCorners       Pointer to the number of corners in the source image.
pSpec             Pointer to the specification structure.

Description

This function converts two-dimensional image with corners to an array of structures. The result is stored in pDst.

For an example on how to use this function, refer to the example provided with the FastN function description.

Return Values

ippStsNoErr    Indicates no error. Any other value indicates an error.
ippStsNullPtrErr Indicates an error when:
                   • pSrcCorner, pDst, pNumCorners, or pSpec is NULL
                   • pSrcScore is NULL if option is not equal to IPP_FASTN_SCORE_MODE0
ippStsSizeErr  Indicates an error when srcRoiSize is less than, or equal to zero.
ippContextMatchErr Indicates an error when the specification structure does not match the operation.
ippDataTypeErr Indicates an error when dataType has an illegal value.
ippNumChannelsErr Indicates an error when numChannels has an illegal value.
ippOutOfRangeErr Indicates an error when orientationBins or N has an illegal value.
ippBadArgsErr   Indicates an error when option or circleRadius has an illegal value.
ippThresholdErr Indicates an error when threshold is negative.

See Also

FastN   Detects corners in an image using the FastN algorithm.

HarrisCornerGetBufferSize

Calculates the size of the temporary buffer for the ippiHarrisCorner function.
Syntax

IppStatus ippiHarrisCornerGetBufferSize(IppiSize roiSize, IppiMaskSize filterMask, Ipp32u avgWndSize, IppDataType dataType, int numChannels, int* pBufferSize);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

roiSize    Size of the source and destination image ROI in pixels.
filterMask Size of the derivative filter aperture. Possible values are ippMskSize3x3 and ippMskSize5x5.
avgWndSize Linear size of a neighborhood block for averaging.
dataType   Data type of the source image. Possible values are ipp8u and ipp32f.
numChannels Number of channels in the images. Possible value is 1.
pBufferSize Pointer to the size (in bytes) of the external work buffer.

Description

This function calculates the size of the temporary buffer needed for the HarrisCorner function.

Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error when pBufferSize is NULL.
ippStsSizeErr Indicates an error in the following cases:
• when roiSize is less than, or equal to zero
• when avgWndSize is equal to zero
ippStsMaskSizeErr Indicates an error when filterMask has an illegal value.
ippStsDataTypeErr Indicates an error when dataType has an illegal value.
ippStsNumChannelsErr Indicates an error when numChannels has an illegal value.

See Also

HarrisCorner  Implements Harris corner detection algorithm.

HarrisCorner

Implements Harris corner detection algorithm.
Syntax
IppStatus ippiHarrisCorner_8u32f_C1R(const Ipp8u* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiDifferentialKernel filterType, IppiMaskSize filterMask, Ipp32u avgWndSize, float k, float scale, IppiBorderType borderType, Ipp8u borderValue, Ipp8u* pBuffer);
IppStatus ippiHarrisCorner_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, IppiDifferentialKernel filterType, IppiMaskSize filterMask, Ipp32u avgWndSize, float k, float scale, IppiBorderType borderType, Ipp32f borderValue, Ipp8u* pBuffer);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
pSrc
    Pointer to the source image.
srcStep
    Distance, in bytes, between the starting points of consecutive lines in the source image.
pDst
    Pointer to the destination image.
dstStep
    Distance, in bytes, between the starting points of consecutive lines in the destination image.
roiSize
    Size of the source and destination image ROI in pixels.
filterType
    Type of the derivative operator. Possible values are:
    ippKernelSobel      Sobel filter
    ippKernelScharr     Scharr filter
    ippKernelCentralDiff Central differences operator
filterMask
    Size of the derivative filter aperture. The list of possible values depends on the filterType value:

<table>
<thead>
<tr>
<th>Filter Type</th>
<th>Filter Mask</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippKernelSobel</td>
<td>ippMskSize3x3, ippMskSize5x5</td>
</tr>
<tr>
<td>ippKernelScharr</td>
<td>ippMskSize3x3</td>
</tr>
<tr>
<td>ippKernelCentralDiff</td>
<td>ippMskSize3x3</td>
</tr>
</tbody>
</table>

avgWndSize
    Linear size of a neighborhood block for averaging.
k
    Harris detector free coefficient.
scale
    Destination image scale factor.
borderType
    Type of border. Possible values are:
    ippBorderConst   Values of all border pixels are set to constant.
ippBorderRepl  Border is replicated from the edge pixels.
ippBorderInMem  Border is obtained from the source image pixels in memory.
ippBorderMirror  Border pixels are mirrored from the source image boundary pixels.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderRepl or ippBorderConst and the following flags:

- ippBorderInMemTop
- ippBorderInMemBottom
- ippBorderInMemLeft
- ippBorderInMemRight

Each of these flags means that for the corresponding border the outside pixels of the source image are in memory.

borderValue  Constant value(s) to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type. The ippiHarrisCorner function uses the specified constant value only at the first stage of the algorithm. At the third stage, the function uses zero constant border.

pBuffer  Pointer to the pre-allocated temporary buffer. To calculate the size of the temporary buffer, use the HarrisCornerGetBufferSize function.

Description

This function goes through the following stages to implement the Harris corner detection algorithm:

1. Computes $I(x,y)_x$ and $I(x,y)_y$ gradients for each $(x, y)$ pixel of the image. The function computes gradients using the derivative operator specified by the filterType and filterMask parameters.

2. Computes products of the gradients at each $(x, y)$ pixel of the image:

   $I_{xx}(x,y) = I_x(x,y) \ast I_x(x,y)$,
   $I_{yy}(x,y) = I_y(x,y) \ast I_y(x,y)$,
   $I_{xy}(x,y) = I_x(x,y) \ast I_y(x,y)$.

3. Performs averaging of the products of gradients over a rectangular neighborhood block at each pixel of the image. The block size is specified by the avgWndSize value.

   $S_{xx}^{(x,y)} = \sum_{y'} \sum_{x'} I_{xx}(x',y')$,
   $S_{xy}^{(x,y)} = \sum_{y'} \sum_{x'} I_{xy}(x',y')$,
   $S_{yy}^{(x,y)} = \sum_{y'} \sum_{x'} I_{yy}(x',y')$.

4. Defines 2x2 gradient covariance matrix $H^{(x,y)}$ over a rectangular neighborhood block for each $(x, y)$ pixel of the image.

   $H^{(x,y)} = \begin{pmatrix}
   S_{xx}^{(x,y)} & S_{xy}^{(x,y)} \\
   S_{xy}^{(x,y)} & S_{yy}^{(x,y)}
   \end{pmatrix}$

5. Computes the corner response at each pixel of the image:
\[ \text{dst}(x, y) = \det H^{(x,y)} - k \ast (\text{tr} H^{(x,y)})^2 \]

where

\( k \) is the Harris detector free parameter.

The first and third stages of the function algorithm are filtering operations; they use border processing approach that is specified by the \texttt{borderType} parameter.

Before using this function, compute the size of the temporary work buffer using the \texttt{HarrisCornerGetBufferSize} function.

**Return Values**

- \texttt{ippStsNoErr}
  - Indicates no error. Any other value indicates an error or a warning.
- \texttt{ippStsNullPtrErr}
  - Indicates an error when \texttt{pSrc}, \texttt{pDst}, or \texttt{pBufferSize} is \texttt{NULL}.
- \texttt{ippStsSizeErr}
  - Indicates an error in the following cases:
    - when \texttt{roiSize} is less than, or equal to zero
    - when \texttt{avgWndSize} is equal to zero
- \texttt{ippStsNotEvenStepErr}
  - Indicates an error when one of the step values is not divisible by 4 for floating point images.
- \texttt{ippStsFilterTypeErr}
  - Indicates an error when \texttt{filterType} has an illegal value.
- \texttt{ippStsMaskSizeErr}
  - Indicates an error when \texttt{filterMask} has an illegal value.
- \texttt{ippStsBorderErr}
  - Indicates an error when \texttt{borderType} has an illegal value.
- \texttt{ippStsStepErr}
  - Indicates an error when \texttt{srcStep} or \texttt{dstStep} has a negative value.
- \texttt{ippStsInplaceModeNotSupportedErr}
  - Indicates an error when \texttt{pSrc} and \texttt{pDst} point to the same image.

**Example**

The code example below demonstrates how to use the \texttt{ippiHarrisCorner_8u32f_C1R} and \texttt{ippiHarrisCornerGetBufferSize} functions.

```c
...  
int    bufSize = 0;
Ipp8u* pBuffer  = 0;
Ipp32u numChannels = 1;
IppStatus status = ippStsNoErr;
IppiBorderType borderType = ippBorderRepl;
IppiDifferentialKernel filterType = ippFilterSobel;
IppiMaskSize filterMask = ippMskSize5x5;
Ipp32u avgWndSize = 3;
Ipp32f scale = 1.0f;

/* Computes the temporary work buffer size */
status = ippiHarrisCornerGetBufferSize(roiSize, filterMask, avgWndSize, ipp8u, numChannels, &bufSize);

/* Memory allocation */
```
if (status != ippStsNoErr) pBuffer = ippsMalloc_8u(bufSize);

if (pBuffer != NULL) {
    /* Harris Corner processing */
    status = ippiHarrisCorner_8u32f_C1R(pSrc, srcStep, pDst, dstStep, roiSize, filterType,
        filterMask, avgWndSize, 0.04f,
        scale, borderType, 0, pBuffer);

    ippsFree(pBuffer);
}

See Also

HarrisCornerGetBufferSize Calculates the size of the temporary buffer for the ippiHarrisCorner function.

Canny Edge Detector

This subsection describes a classic edge detector proposed by J. Canny, see [Canny86]. The detector uses a grayscale image as an input and outputs a black-and-white image, where non-zero pixels mark detected edges. The algorithm consists of three stages described below.

Stage 1: Differentiation

The image data is differentiated in $x$ and $y$ directions. From the computed $x$ and $y$ gradient components, Canny edge detector functions calculate the magnitude and angle of the gradient vector.

NOTE
The ippiSobel functions perform the first stage and Canny edge detector functions use their output.

Stage 2: Non-Maximum Suppression

With the rate of intensity change found at each point in the image, edges must be placed at the points of maximum values of gradient magnitude. It is preferable to suppress non-maximum points that are perpendicular to the edge direction, rather than parallel to the edge direction, as the edge is strong along an extended contour.

The algorithm starts off with sorting the direction of gradient to one of four sectors shown in the figure below.

Gradient Sectors

![Gradient Sectors Diagram]
The algorithm passes a 3x3 neighborhood across the magnitude array. At each point, the center element of the neighborhood is compared with its two neighbors along the line of the gradient given by the sector value. If the central value is not greater than the neighbors, it is suppressed.

### Stage 3: Edge Thresholding

The Canny operator uses the so-called “hysteresis” thresholding. Most thresholders use a single threshold limit, which means that if the edge values fluctuate above and below this value, the line appears broken. This phenomenon is commonly referred to as “streaking”. Hysteresis counters streaking by setting an upper and lower edge value limit. Considering a line segment, if a value lies above the upper threshold limit, it is immediately accepted. If the value lies below the low threshold, it is rejected. Points which lie between the two limits are accepted if they are connected to pixels which are also accepted. The likelihood of streaking is small, since the line segment points must fluctuate above the upper limit and below the lower limit for streaking to occur.

J. Canny recommends the ratio of high to low limit be in the range two or three to one, based on predicted signal-to-noise ratios.

**Example** shows how to use the Intel IPP functions for the Canny edge detector.

#### CannyBorderGetSize

*Calculates the size of the temporary buffer for the ippiCannyBorder function.*

**Syntax**

```c
IppStatus ippiCannyBorderGetSize(IppiSize roiSize, IppiDifferentialKernel filterType, IppiMaskSize mask, IppDataType dataType, int* pBufferSize);
```

**Include Files**

`ippcv.h`

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- `roiSize`  
  Size of the image ROI in pixels.
- `filterType`  
  Type of the filter to be applied. Possible values are ippFilterSobel and ippFilterScharr.
- `mask`  
  The size of the mask. Possible values are ippMskSize3x3 and ippMskSize5x5.
- `dataType`  
  Data type of the image. Possible value is ipp8u.
- `pBufferSize`  
  Pointer to the variable that returns the size of the temporary buffer.

**Description**

This function calculates the size of the temporary buffer needed for the CannyBorder function.
Return Values

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error when the pBufferSize pointer is NULL.
- ippStsMaskSizeErr: Indicates an error when mask has an illegal value.
- ippStsDataTypeErr: Indicates an error when dataType has an illegal value.
- ippStsSizeErr: Indicates an error when roiSize has a field with a zero or negative value.

See Also

CannyBorder  Implements Canny algorithm for edge detection.

Syntax

IppStatus ippiCannyBorder_8u_C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, IppiDifferentialKernel filterType, IppiMaskSize mask, IppiBorderType borderType, Ipp8u borderValue, Ipp32f lowThresh, Ipp32f highThresh, IppNormType norm, Ipp8u* pBuffer);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- pSrc: Pointer to the source image.
- srcStep: Distance, in bytes, between the starting points of consecutive lines in the source image.
- pDst: Pointer to the destination image.
- dstStep: Distance, in bytes, between the starting points of consecutive lines in the destination image.
- roiSize: Size of the source image ROI in pixels.
- filterType: Type of the filter to be applied. Possible values are ippFilterSobel and ippFilterScharr.
- mask: The size of the mask. Possible values are ippMskSize3x3 and ippMskSize5x5 for ippFilterSobel, and ippMskSize3x3 for ippFilterScharr.
- borderType: Type of border. Possible values are:
  - ippBorderConst: Values of all border pixels are set to constant.
  - ippBorderRepl: Border is replicated from the edge pixels.
ippBorderInMem  Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderRepl and ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight.

borderValue  Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

lowThresh  Lower threshold for edges detection.

highThresh  Upper threshold for edges detection.

norm  Normalization mode. Possible values are ippNormL1 and ippNormL2.

pBuffer  Pointer to the pre-allocated temporary buffer. To calculate the size of the temporary buffer, use the CannyBorderGetSize function.

Description
This function operates with ROI (see Regions of Interest in Intel IPP). This function finds edges in the ROI of the source image with the user-defined border types using the Canny edge detector algorithm. The output image is stored in pDst.

Before using this function, compute the size of the temporary work buffer using the CannyBorderGetSize function.

Return Values

ippStsNoErr  Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  Indicates an error when one of the specified pointers is NULL.

ippStsMaskSizeErr  Indicates an error when mask has an illegal value.

ippStsSizeErr  Indicates an error when roiSize has a field with a zero or negative value.

ippStsStepErr  Indicates an error when srcStep or dstStep is less than roi.width*<pixelSize>.

ippStsBadArgErr  Indicates an error when lowThresh is negative, or highThresh is less than lowThresh.

ippStsNotEvenStepErr  Indicates an error when one of the step values is not divisible by 2 for 16s images, and by 4 for 32f images.

Example
To better understand usage of the ippiCannyBorder function, refer to the CannyBorder.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

See Also
CannyBorderGetSize  Calculates the size of the temporary buffer for the ippiCannyBorder function.

CannyGetSize  Calculates size of temporary buffer for the ippiCanny function.
Syntax

IppStatus ippiCannyGetSize(IppiSize roiSize, int* pBufferSize);
IppStatus ippiCannyGetSize_L(IppiSizeL roi, IppSizeL* bufferSize);

Include Files

ippcv.h

Flavors with the _L suffix: ippcv_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

roiSize, roi  Size of the image ROI, in pixels.
pBufferSize, bufferSize  Pointer to the computed size of the temporary buffer.

Description

This function calculates the size of a temporary buffer for the ippiCanny function.

Return Values

ippStsNoErr  Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr  Indicates an error condition if pBufferSize pointer is NULL.
ippStsSizeErr  Indicates an error condition if pRoiSize has a field with zero or negative value.

Canny

*Implements Canny algorithm for edge detection.*

Syntax

IppStatus ippiCanny_16s8u_C1R(Ipp16s* pSrcDx, int srcDxStep, Ipp16s* pSrcDy, int srcDyStep, Ipp8u* pDstEdges, int dstEdgeStep, IppSize roiSize, Ipp32f lowThreshold, Ipp32f highThreshold, Ipp8u* pBuffer);
IppStatus ippiCanny_32f8u_C1R(Ipp32f* pSrcDx, int srcDxStep, Ipp32f* pSrcDy, int srcDyStep, Ipp8u* pDstEdges, int dstEdgeStep, IppSize roiSize, Ipp32f lowThreshold, Ipp32f highThreshold, Ipp8u* pBuffer);

Platform-aware functions

IppStatus ippiCanny_16s8u_C1R_L(Ipp16s* pSrcDx, IppSizeL srcDxStep, Ipp16s* pSrcDy, IppSizeL srcDyStep, Ipp8u* pDstEdges, IppSizeL dstEdgeStep, IppSizeL roiSize, Ipp32f lowThreshold, Ipp32f highThreshold, IppNormType norm, Ipp8u* pBuffer);
IppStatus ippiCanny_32f8u_C1R_L(Ipp32f* pSrcDx, IppSizeL srcDxStep, Ipp32f* pSrcDy, IppSizeL srcDyStep, Ipp8u* pDstEdges, IppSizeL dstEdgeStep, IppSizeL roiSize, Ipp32f lowThreshold, Ipp32f highThreshold, IppNormType norm, Ipp8u* pBuffer);

Include Files

ippcv.h
Flavors with the \_L suffix: ippcv\_L.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrcDx**: Pointer to the source image ROI x-derivative.
- **srcDxStep**: Distance in bytes between starts of consecutive lines in the source image pSrcDx.
- **pSrcDy**: Pointer to the source image ROI y-derivative.
- **srcDyStep**: Distance, in bytes, between the starting points of consecutive lines in the source image pSrcDy.
- **pDstEdges**: Pointer to the output array of the detected edges.
- **dstEdgeStep**: Distance, in bytes, between the starting points of consecutive lines in the output image.
- **roiSize**: Size of the source image ROI in pixels.
- **lowThreshold**: Lower threshold for edges detection.
- **highThreshold**: Upper threshold for edges detection.
- **norm**: Normalization type; supported values: ippNormL1 and ippNormL2.
- **pBuffer**: Pointer to the pre-allocated temporary buffer.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP). This function finds edges in the source image ROI and stores them into the output image pDstEdges using the Canny algorithm. The function requires a temporary working buffer; its size should be computed previously by calling the function ippiCannyGetSize.

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if pRoiSize has a field with zero or negative value.
- **ippStsStepErr**: Indicates an error condition if srcDxStep, srcDyStep or dstEdgeStep is less than roi.width*<pixelSize>.
- **ippStsBadArgErr**: Indicates an error when lowThresh is negative or highThresh is less than lowThresh.
- **ippStsNotEvenStepErr**: Indicates an error condition if one of the step values is not divisible by 2 for 16s images, and by 4 for 32f images.

**Example**

To better understand usage of the ippiCanny function, refer to the Canny.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.
EigenValsVecsGetBufferSize

Calculates size of temporary buffer for the functionippiEigenValsVecs.

**Syntax**

IppStatusippiEigenValsVecsGetBufferSize_32f_C1R(IppiSizeroiSize, intapertureSize, intavgWindow, int*pBufferSize);

IppStatusippiEigenValsVecsGetBufferSize_8u32f_C1R(IppiSizeroiSize, intapertureSize, intavgWindow, int*pBufferSize);

**Include Files**

ippcv.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **roiSize**
  Size of the source image ROI in pixels.

- **apertureSize**
  Size (pixels) of the derivative operator used by the function, possible values are 3 or 5.

- **avgWindow**
  Size of the blurring window in pixels, possible values are 3 or 5.

- **pBufferSize**
  Pointer to the variable that returns the size of the temporary buffer.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function calculates the size of a temporary buffer to be used by the functionippiEigenValsVecs.

**Caution**

The parameters apertureSize and avgWindow must be the same for both functionsippiEigenValsVecsGetBufferSize andippiEigenValsVecs.

Example 14-2 shows how to use the functionippiEigenValsVecsGetBufferSize.

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**
  Indicates an error condition if one of the specified pointers is NULL.

- **ippStsSizeErr**
  Indicates an error condition if roiWidth has zero or negative value, or if apertureSize or avgWindow has an illegal value.

EigenValsVecsBorder

Calculates eigen values and eigen vectors of image blocks for corner detection.
**Syntax**

IppStatus ippiEigenValsVecsBorder_8u32f_C1R(const Ipp8u* pSrc, int srcStep, Ipp32f* pEigenVV, int eigStep, IppiSize roiSize, IppiKernelType kernType, int apertureSize, int avgWindow, IppiBorderType borderType, Ipp8u borderValue, Ipp8u* pBuffer);

IppStatus ippiEigenValsVecsBorder_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pEigenVV, int eigStep, IppiSize roiSize, IppiKernelType kernType, int apertureSize, int avgWindow, IppiBorderType borderType, Ipp32f borderValue, Ipp8u* pBuffer);

**Include Files**

ippcv.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

**Parameters**

- **pSrc**
  - Pointer to the source image ROI.

- **srcStep**
  - Distance, in bytes, between the starting points of consecutive lines in the source image.

- **pEigenVV**
  - Image to store the results.

- **eigStep**
  - Distance, in bytes, between the starting points of consecutive lines in the output image.

- **roiSize**
  - Size of the source image ROI, in pixels.

- **kernType**
  - Specifies the type of kernel used to compute derivatives, possible values are:
    - ippKernelSobel
      - Sobel kernel 3x3 or 5x5
    - ippKernelSobelNeg
      - Negative Sobel kernel 3x3 or 5x5
    - ippKernelScharr
      - Scharr kernel 3x3

- **apertureSize**
  - Size of the derivative operator in pixels, possible values are 3 or 5.

- **border**
  - Type of image border. Possible values:
    - ippBorderConst
      - Values of all border pixels are set to a constant.
    - ippBorderRepl
      - Border is replicated from the edge pixels.

- **borderValue**
  - Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

- **avgWindow**
  - Size of the blurring window in pixels, possible values are 3 or 5.

- **pBuffer**
  - Pointer to the temporary buffer.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).
This function takes a block around the pixel and computes the first derivatives $D_x$ and $D_y$. This operation is performed for every pixel of the image using either Sobel or Scharr kernel in accordance with the `kernType` parameter. The `apertureSize` parameter specifies the size of the Sobel kernel. If this parameter is set to 3, the function used 3x3 kernel, if it is set to 5, the function uses 5x5 kernel. Only 3x3 size is available for the Scharr kernel, therefore the parameter `apertureSize` must be set to 3 if the Scharr kernel is used.

**Caution**
If the parameter `apertureSize` is set to 5 for operation with the Scharr kernel, the function returns error status.

The function computes eigen values and vectors of the following matrix:

$$
\begin{bmatrix}
\sum D_x^2 & \sum D_x D_y \\
\sum D_x D_y & \sum D_y^2
\end{bmatrix}
$$

The summation is performed over the full block with averaging over the blurring window with size `avgWindow`.

The image `eigenVV` has the following format. For every pixel of the source image it contains six floating-point values - $\lambda_1, \lambda_2, x_1, y_1, x_2, y_2$. These values are defined as follows:

- $\lambda_1, \lambda_2$  
  Eigen values of the above matrix ($\lambda_1 \geq \lambda_2 \geq 0$).

- $x_1, y_1$  
  Coordinates of the normalized eigen vector corresponding to $\lambda_1$.

- $x_2, y_2$  
  Coordinates of the normalized eigen vector corresponding to $\lambda_2$.

In case of a singular matrix or when one eigen value is much smaller than the second one, all these six values are set to 0.

The function requires a temporary work buffer. Before using this function, compute the size of the buffer using the `ippiEigenValsVecsGetBufferSize` function.

**Caution**
The parameters `apertureSize` and `avgWindow` must be the same for both functions `ippiEigenValsVecsGetBufferSize` and `ippiEigenValsVecsBorder`.

**Return Values**

- `ippiStsNoErr`  
  Indicates no error. Any other value indicates an error or a warning.

- `ippiStsNullPtrErr`  
  Indicates an error condition if one of the specified pointers is NULL.

- `ippiStsSizeErr`  
  Indicates an error condition if `pRoiSize` has a field with zero or negative value, or if `apertureSize` or `avgWindow` has an illegal value; or if `kernType` has a wrong value.

- `ippiStsStepErr`  
  Indicates an error condition if `srcStep` is less than `roiSize.width*<pixelSize>`, or `eigStep` is less than `roiSize.width*sizeof(Ipp32f) * 6`. 

Indicates an error condition if steps for floating-point images are not divisible by 4.
Indicates an error if borderType has an illegal value.

See Also
Regions of Interest in Intel IPP
EigenValsVecsGetBufferSize Calculates size of temporary buffer for the function ippiEigenValsVecs.

EigenValsVecs
Calculates eigen values and eigen vectors of image blocks for corner detection.

Syntax
IppStatus ippiEigenValsVecs_8u32f_C1R(const Ipp8u* pSrc, int srcStep, Ipp32f* pEigenVV, int eigStep, IppiSize roiSize, IppiKernelType kernType, int apertureSize, int avgWindow, Ipp8u* pBuffer);
IppStatus ippiEigenValsVecs_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pEigenVV, int eigStep, IppiSize roiSize, IppiKernelType kernType, int apertureSize, int avgWindow, Ipp8u* pBuffer);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
pSrc
Pointer to the source image ROI.
srcStep
Distance, in bytes, between the starting points of consecutive lines in the source image.
pEigenVV
Image to store the results.
eigStep
Distance, in bytes, between the starting points of consecutive lines in the output image.
roiSize
Size of the source image ROI, in pixels.
kernType
Specifies the type of kernel used to compute derivatives, possible values are:
ippKernelSobel Sobel kernel 3x3 or 5x5
ippKernelSobelNeg Negative Sobel kernel 3x3 or 5x5
ippKernelScharr Scharr kernel 3x3
apertureSize
Size of the derivative operator in pixels, possible values are 3 or 5.
avgWindow
Size of the blurring window in pixels, possible values are 3 or 5.
pBuffer
Pointer to the temporary buffer.
Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function takes a block around the pixel and computes the first derivatives $D_x$ and $D_y$. This operation is performed for every pixel of the image using either Sobel or Scharr kernel in accordance with the `kernType` parameter. The `apertureSize` parameter specifies the size of the Sobel kernel. If this parameter is set to 3, the function used 3x3 kernel, if it is set to 5, the function uses 5x5 kernel. Only 3x3 size is available for the Scharr kernel, therefore the parameter `apertureSize` must be set to 3 if the Scharr kernel is used.

**Caution**

If the parameter `apertureSize` is set to 5 for operation with the Scharr kernel, the function returns error status.

The function computes eigen values and vectors of the following matrix:

$$
\begin{bmatrix}
\sum D_x^2 & \sum D_x D_y \\
\sum D_x D_y & \sum D_y^2
\end{bmatrix},
$$

The summation is performed over the full block with averaging over the blurring window with size `avgWindow`.

The image `eigenVV` has the following format. For every pixel of the source image it contains six floating-point values - $\lambda_1$, $\lambda_2$, $x_1$, $y_1$, $x_2$, $y_2$. These values are defined as follows:

- $\lambda_1$, $\lambda_2$  
  Eigen values of the above matrix ($\lambda_1 \geq \lambda_2 \geq 0$).
- $x_1$, $y_1$  
  Coordinates of the normalized eigen vector corresponding to $\lambda_1$.
- $x_2$, $y_2$  
  Coordinates of the normalized eigen vector corresponding to $\lambda_2$.

In case of a singular matrix or when one eigen value is much smaller than the second one, all these six values are set to 0.

The function requires a temporary working buffer; its size should be computed previously by calling the function `ippiEigenValsVecsGetBufferSize`.

**Caution**

The parameters `apertureSize` and `avgWindow` must be the same for both functions `ippiEigenValsVecsGetBufferSize` and `ippiEigenValsVecs`.

**Return Values**

- `ippStsNoErr`  
  Indicates no error. Any other value indicates an error or a warning.

- `ippStsNullPtrErr`  
  Indicates an error condition if one of the specified pointers is NULL.

- `ippStsSizeErr`  
  Indicates an error condition if `pRoiSize` has a field with zero or negative value, or if `apertureSize` or `avgWindow` has an illegal value; or if `kernType` has wrong value.
Indicates an error condition if srcStep is less than roiSize.width*<pixelSize>, or eigStep is less than roiSize.width*sizeof(ipp32f)*6.

Indicates an error condition if steps for floating-point images are not divisible by 4.

Example
To better understand usage of the ippiEigenValsVecs function, refer to the EigenValsVecs.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples:

MinEigenValGetBufferSize
Calculates size of temporary buffer for the function ippiMinEigenVal.

Syntax
IppStatus ippiMinEigenValGetBufferSize_32f_C1R(IppSize roiSize, int apertureSize, int avgWindow, int* pBufferSize);
IppStatus ippiMinEigenValGetBufferSize_8u32f_C1R(IppSize roiSize, int apertureSize, int avgWindow, int* pBufferSize);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters
roiSize          Size of the source image ROI in pixels.
apertureSize    Size (in pixels) of the derivative operator used by the function, possible values are 3 or 5.
avgWindow       Size of the blurring window in pixels, possible values are 3 or 5.
pBufferSize     Pointer to the variable that returns the size of the temporary buffer.

Description
This function operates with ROI (see Regions of Interest in Intel IPP). This function calculates the size of a temporary buffer to be used by the function ippiMinEigenVal.

Caution
The parameters apertureSize and avgWindow must be the same for both functions ippiMinEigenValGetBufferSize and ippiMinEigenVal.

Return Values
ippStsNoErr     Indicates no error. Any other value indicates an error or a warning.
Indicates an error condition if one of the specified pointers is NULL.

Indicates an error condition if \textit{roiWidth} has a zero or negative value, or if \textit{apertureSize} or \textit{avgWindow} has an illegal value.

\textbf{MinEigenValBorder}

\textit{Calculates the minimal eigen value of image blocks for corner detection.}

\textbf{Syntax}

\begin{verbatim}
IppStatus ippiMinEigenValBorder_8u32f_C1R(const Ipp8u* pSrc, int srcStep, Ipp32f* pMinEigenVal, int minValStep, IppiSize roiSize, IppiKernelType kernType, int apertureSize, int avgWindow, IppiBorderType borderType, Ipp8u borderValue, Ipp8u* pBuffer);

IppStatus ippiMinEigenValBorder_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pMinEigenVal, int minValStep, IppiSize roiSize, IppiKernelType kernType, int apertureSize, int avgWindow, IppiBorderType borderType, Ipp32f borderValue, Ipp8u* pBuffer);
\end{verbatim}

\textbf{Include Files}

ippcv.h

\textbf{Domain Dependencies}

\textbf{Headers:} ippcore.h, ippvm.h, ipps.h,ippi.h

\textbf{Libraries:} ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

\textbf{Parameters}

\begin{itemize}
    \item \textit{pSrc}  
        Pointer to the source image ROI.
    \item \textit{srcStep}  
        Distance, in bytes, between the starting points of consecutive lines in the source image.
    \item \textit{pMinEigenVal}  
        Pointer to the image that is filled with the minimal eigen values.
    \item \textit{minValStep}  
        Distance, in bytes, between the starting points of consecutive lines in the output image.
    \item \textit{roiSize}  
        Size of the source image ROI in pixels.
    \item \textit{kernType}  
        Specifies the type of kernel used to compute derivatives, possible values are:
        \begin{itemize}
            \item ippKernelSobel  
                Sobel kernel 3x3 or 5x5
            \item ippKernelSobelNeg  
                Negative Sobel kernel 3x3 or 5x5
            \item ippKernelScharr  
                Scharr kernel 3x3
        \end{itemize}
    \item \textit{apertureSize}  
        Size of the derivative operator, in pixels; possible values are 3 or 5.
    \item \textit{avgWindow}  
        Size of the averaging window, in pixels; possible values are 3 or 5.
    \item \textit{borderType}  
        Type of image border. Possible values:
        \begin{itemize}
            \item ippBorderConst  
                Values of all border pixels are set to a constant.
        \end{itemize}
\end{itemize}
**ippBorderRepl**
Border is replicated from the edge pixels.

**ippBorderMirror**
Border pixels are mirrored from the source image boundary pixels.

**borderValue**
Constant value to assign to pixels of the constant border. This parameter is applicable only to the **ippBorderConst** border type.

**pBuffer**
Pointer to the temporary buffer.

**Description**
This function operates with ROI (see **Regions of Interest in Intel IPP**). This function takes a block around the pixel and computes the first derivatives \( D_x \) and \( D_y \). This operation is performed for every pixel of the image using either Sobel or Scharr kernel in accordance with the **kernType** parameter. The **apertureSize** parameter specifies the size of the Sobel kernel. If **apertureSize** is set to 3, the function uses 3x3 kernel, if it is set to 5, the function uses 5x5 kernel. Only 3x3 size is available for the Scharr kernel, therefore the parameter **apertureSize** must be set to 3 if the Scharr kernel is used.

<table>
<thead>
<tr>
<th>Caution</th>
</tr>
</thead>
<tbody>
<tr>
<td>If the parameter <strong>apertureSize</strong> is set to 5 for operation with the Scharr kernel, the function returns error status.</td>
</tr>
</tbody>
</table>

The function computes the minimal eigen value \( \lambda (\lambda \geq 0) \) of the following matrix:

\[
\begin{pmatrix}
\Sigma D_x^2 & \Sigma D_x D_y \\
\Sigma D_x D_y & \Sigma D_y^2
\end{pmatrix}
\]

The summation is performed over the full block with averaging over the blurring window with size **avgWindow**.

The function requires a temporary work buffer. Before using this function, compute the size of the work buffer using the **ippiMinEigenValGetBufferSize** function.

<table>
<thead>
<tr>
<th>Caution</th>
</tr>
</thead>
<tbody>
<tr>
<td>The parameters <strong>apertureSize</strong> and <strong>avgWindow</strong> must be the same for both functions <strong>ippiMinEigenValGetBufferSize</strong> and <strong>ippiMinEigenValBorder</strong>.</td>
</tr>
</tbody>
</table>

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**
  Indicates an error condition if one of the specified pointers is NULL.

- **ippStsSizeErr**
  Indicates an error condition if **pRoiSize** has a field with zero or negative value, or if **apertureSize** or **avgWindow** has an illegal value; or if **kernType** has wrong value.

- **ippStsStepErr**
  Indicates an error condition if **srcStep** is less than \( roiSize.width \times <\text{pixelSize}> \), or **eigenvvStep** is less than \( roiSize.width \times \text{sizeof}(\text{Ipp32f}) \).
IppStsNotEvenStepErr  Indicates an error condition if steps for floating-point images are not divisible by 4.
IppStsBorderErr  Indicates an error if borderType has an illegal value.

See Also
Regions of Interest in Intel IPP
MinEigenValGetBufferSize  Calculates size of temporary buffer for the function ippiMinEigenVal.

MinEigenVal
Calculates the minimal eigen value of image blocks for corner detection.

Syntax
IppStatus ippiMinEigenVal_8u32f_C1R(const Ipp8u* pSrc, int srcStep, Ipp32f* pMinEigenVal, int minValStep, IppiSize roiSize, IppiKernelType kernType, int apertureSize, int avgWindow, Ipp8u* pBuffer);
IppStatus ippiMinEigenVal_32f_C1R(const Ipp32f* pSrc, int srcStep, Ipp32f* pMinEigenVal, int minValStep, IppiSize roiSize, IppiKernelType kernType, int apertureSize, int avgWindow, Ipp8u* pBuffer);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
pSrc  Pointer to the source image ROI.
srcStep  Distance in bytes between starts of consecutive lines in the source image.
pMinEigenVal  Pointer to the image that is filled with the minimal eigen values.
minValStep  Distance in bytes between starts of consecutive lines in the output image.
roiSize  Size of the source image ROI in pixels.
kernType  Specifies the type of kernel used to compute derivatives, possible values are:
ippKernelSobel  Sobel kernel 3x3 or 5x5
ippKernelSobelNeg  Negative Sobel kernel 3x3 or 5x5
ippKernelScharr  Scharr kernel 3x3
apertureSize  Size of the derivative operator in pixels, possible values are 3 or 5.
avgWindow  Size of the averaging window in pixels, possible values are 3 or 5.
pBuffer  Pointer to the temporary buffer.
Description

This function operates with ROI (see Regions of Interest in Intel IPP). This function takes a block around the pixel and computes the first derivatives $D_x$ and $D_y$. This operation is performed for every pixel of the image using either Sobel or Scharr kernel in accordance with the `kernType` parameter. The size of the Sobel kernel may be specified the parameter `apertureSize`. If this parameter is set to 3, the function used 3x3 kernel, if it is set to 5, the function uses 5x5 kernel. Only 3x3 size is available for the Scharr kernel, therefore the parameter `apertureSize` must be set to 3 if the Scharr kernel is used.

**Caution**

If the parameter `apertureSize` is set to 5 for operation with the Scharr kernel, the function returns error status.

Then, the function computes the minimal eigen value $\lambda$ ($\lambda\geq0$) of the following matrix:

$$
\begin{bmatrix}
\Sigma D_x^2 & \Sigma D_x D_y \\
\Sigma D_x D_y & \Sigma D_y^2
\end{bmatrix}
$$

The summation is performed over the full block with averaging over the blurring window with size `avgWindow`.

The function requires a temporary working buffer; its size should be computed previously by calling the function `ippiMinEigenValGetBufferSize`.

**Caution**

The parameters `apertureSize` and `avgWindow` must be the same for both functions `ippiMinEigenValGetBufferSize` and `ippiMinEigenVal`.

**Return Values**

- **ippStsNoErr** Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr** Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr** Indicates an error condition if `pRoiSize` has a field with zero or negative value, or if `apertureSize` or `avgWindow` has an illegal value; or if `kernType` has wrong value.
- **ippStsStepErr** Indicates an error condition if `srcStep` is less than `roiSize.width*<pixelSize>`, or `eigenvvStep` is less than `roiSize.width*sizeof(Ipp32f)`.
- **ippStsNotEvenStepErr** Indicates an error condition if steps for floating-point images are not divisible by 4.

**Histogram of Oriented Gradients (HOG) Descriptor**

Histogram of oriented gradients (HOG) is a feature descriptor used to detect objects in computer vision and image processing. The HOG descriptor technique counts occurrences of gradient orientation in localized portions of an image - detection window, or region of interest (ROI).

Implementation of the HOG descriptor algorithm is as follows:
1. Divide the image into small connected regions called cells, and for each cell compute a histogram of
gradient directions or edge orientations for the pixels within the cell.
2. Discretize each cell into angular bins according to the gradient orientation.
3. Each cell’s pixel contributes weighted gradient to its corresponding angular bin.
4. Groups of adjacent cells are considered as spatial regions called blocks. The grouping of cells into a
block is the basis for grouping and normalization of histograms.
5. Normalized group of histograms represents the block histogram. The set of these block histograms
represents the descriptor.

The following figure demonstrates the algorithm implementation scheme:

Computation of the HOG descriptor requires the following basic configuration parameters:

- Masks to compute derivatives and gradients
- Geometry of splitting an image into cells and grouping cells into a block
- Block overlapping
- Normalization parameters

According to [Dalal05] the recommended values for the HOG parameters are:

- 1D centered derivative mask [-1, 0, +1]
- Detection window size is 64x128
- Cell size is 8x8
- Block size is 16x16 (2x2 cells)

Intel® IPP implementation does not assume any default fixed set of parameters values. The IppiHOGConfig
structure defines HOG parameters used in Intel IPP functions.

There are some limitations to the values of basic configuration parameters:

```c
#define IPP_HOG_MAX_CELL   (16)  /* max size of cell */
#define IPP_HOG_MAX_BLOCK  (64)  /* max size of block */
#define IPP_HOG_MAX_BINS   (16)  /* max number of bins */
```

See Also

Structures and Enumerators
HOGGetSize

**Computes the size of the HOG context structure.**

**Syntax**

\[
\text{IppStatus ippiHOGGetSize(const IppiHOGConfig* pConfig, int* pHOGSpecSize);}\]

**Include Files**

ippi.h

**Domain Dependencies**

- **Headers:** ippcore.h, ippvm.h, ipps.h
- **Libraries:** ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **pConfig**
  - Pointer to the HOG context structure.
- **pHOGSpecSize**
  - Pointer to the size of the HOG context structure, in bytes.

**Description**

This function checks the parameters of the HOG configuration and computes the size, in bytes, of the HOG context structure `pHOGSpecSize`.

For an example on how to use this function, refer to the example provided with the HOG function description.

**Return Values**

- **ippiStsNoErr**
  - Indicates no error. Any other value indicates an error.
- **ippiStsNullPtrErr**
  - Indicates an error when one of the specified pointers is NULL.
- **ippiStsSizeErr**
  - Indicates an error when one of the `winSize` fields in the `pConfig` parameter has a zero or negative value.
- **ippiStsNotSupportedModErr**
  - Indicates an error in HOG configuration:
    - `cellSize` is less than 2, or more than `IPP_HOG_MAX_CELL`
    - `cellSize` is more than `blockSize`, or `blockSize` is more than `IPP_HOG_MAX_BLOCK`
    - `blockSize` is not a multiple of `cellSize`
    - Block does not have 2x2 cell geometry
    - `blockStride` is not a multiple of `cellSize`
    - Detection window size is not a multiple of `blockStride`
    - `nbins` is less than 2, or more than `IPP_HOG_MAX_BINS`
    - `sigma` or `threshold` value is less than, or equal to zero

**See Also**

HOG  Computes the HOG descriptor.

HOGInit

**Initializes the HOG context structure.**

**Syntax**

\[
\text{IppStatus ippiHOGInit(const IppiHOGConfig* pConfig, IppiHOGSpec* pHOGSpec);}\]
Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pConfig               Pointer to the HOG context structure.
pHOGSpec              Pointer to the HOG context structure.

Description
This function checks the parameters of the HOG configuration and initializes the HOG context structure.
For an example on how to use this function, refer to the example provided with the HOG function description.

Return Values
ippStsNoErr            Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr       Indicates an error when one of the specified pointers is NULL.
ippStsSizeErr          Indicates an error when one of the winSize fields in the pConfig parameter has a zero or negative value.
ippStsNotSupportedModErr Indicates an error in HOG configuration:
  • cellSize is less than 2, or more than IPP_HOG_MAX_CELL
  • cellSize is more than blockSize, or blockSize is more than IPP_HOG_MAX_BLOCK
  • blockSize is not a multiple of cellSize
  • Block does not have 2x2 cell geometry
  • blockStride is not a multiple of cellSize
  • Detection window size is not a multiple of blockStride
  • nbins is less than 2, or more than IPP_HOG_MAX_BINS
  • sigma or threshold value is less than, or equal to zero

See Also
HOG Computes the HOG descriptor.

HOGGetBufferSize
Computes the size of the work buffer for the ippiHOG function.

Syntax
IppStatus ippiHOGGetBufferSize(const IppiHOGSpec* pHOGSpec, IppiSize roiSize, int* pBufferSize);

Include Files
ippi.h
Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- pHOGSpec: Pointer to the HOG context structure.
- roiSize: Maximum size of the source image ROI, in pixels.
- pBufferSize: Pointer to the size of the work buffer, in bytes.

Description
This function computes the size of the work buffer for the HOG function.
For an example on how to use this function, refer to the example provided with the HOG function description.

Return Values

- ippStsNoErr: Indicates no error. Any other value indicates an error.
- ippStsNullPtrErr: Indicates an error when one of the specified pointers is NULL.
- ippStsContextmatchErr: Indicates an error when the context parameter does not match the operation.

See Also
HOG  Computes the HOG descriptor.
HOGGetDescriptorSize  Computes the size of the HOG descriptor.

Syntax

IppStatus ippiHOGGetDescriptorSize(const IppiHOGSpec* pHOGSpec, int* pWinDescriptorSize);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- pHOGSpec: Pointer to the HOG context structure.
- pWinDescriptorSize: Pointer to the size of the descriptor window, in bytes.

Description
This function computes the size of the buffer for a single detection window. If the subsequent call(s) of the HOG function target processing of multiple detection windows, the size of the buffer must be increased proportionally.
For an example on how to use this function, refer to the example provided with the HOG function description.
Return Values

ippStsNoErr  Indicates no error. Any other value indicates an error.
ippStsNullPtrErr  Indicates an error when one of the specified pointers is NULL.
ippStsContextmatchErr  Indicates an error when the context parameter does not match the operation.

See Also

HOG  Computes the HOG descriptor.

HOG  
*Computes the HOG descriptor.*

Syntax

IppStatus ippiHOG_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, IppiSize roiSize, const IppiPoint* pLocation, int nLocations, Ipp32f* pDst, const IppiHOGSpec* pHOGSpec, IppiBorderType borderID, Ipp<srcDatatype> borderValue, Ipp8u* pBuffer);

Supported values for mod:

- 8u32f_C1R
- 16u32f_C1R
- 16s32f_C1R
- 32f_C1R

IppStatus ippiHOG_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep, IppiSize roiSize, const IppiPoint* pLocation, int nLocations, Ipp32f* pDst, const IppiHOGSpec* pHOGCtx, IppiBorderType borderID, Ipp<srcDatatype> borderValue[3], Ipp8u* pBuffer);

Supported values for mod:

- 8u32f_C3R
- 16u32f_C3R
- 16s32f_C3R
- 32f_C3R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- pSrc  Pointer to the source image ROI.
- srcStep  Distance, in bytes, between the starting points of consecutive lines in the source image.
- roiSize  Size of the source image ROI, in pixels.
- pLocation  Pointer to the array with detection window locations.
- nLocations  Number of locations.
- pDst  Pointer to the HOG descriptor.
- pHOGCtx, pHOGSpec  Pointer to the HOG context/specification structure.
- borderID  Type of border. Possible values are:
Values of all border pixels are set to a constant.

Border is replicated from the edge pixels.

Border is obtained from the source image pixels in memory.

Border pixels are mirrored from the source image boundary pixels.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between `ippBorderRepl` and `ippBorderInMemTop`, `ippBorderInMemBottom`, `ippBorderInMemLeft`, `ippBorderInMemRight`.

Constant value to assign to pixels of the constant border. This parameter is applicable only to the `ippBorderConst` border type.

Pointer to the work buffer.

This function computes the HOG descriptor over defined locations of the detection window. Flavors with the `C1` suffix operate on one-channel (gray) images, and `C3` flavors operate on color images.

Before using this function, compute the size of the context structure, work buffer, and descriptor using the `HOGGetSize`, `HOGGetBufferSize`, and `HOGGetDescriptorSize` functions, respectively. To initialize the HOG context structure, use the `HOGInit` function.

Indicates no error. Any other value indicates an error or a warning.

Indicates an error when one of the specified pointers is `NULL`.

Indicates an error when the context parameter does not match the operation.

Indicates an error when `srcStep` is less than, or equal to zero.

Indicates an error when `srcStep` is not divisible by input data type size.

Indicates an error when `borderID` has an illegal value.

Indicates an error when `roiSize` is less than, or equal to zero.

To better understand usage of the `ippiHOG` function, refer to the `HOG.c` example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

**See Also**

- `HOGGetSize` Computes the size of the HOG context structure.
- `HOGGetBufferSize` Computes the size of the work buffer for the `ippiHOG` function.
- `HOGGetDescriptorSize` Computes the size of the HOG descriptor.
- `HOGInit` Initializes the HOG context structure.
Hough Transform

The Hough transform is a general technique that allows to detect the flat curves in binary images [Gon93]. The current version of Intel IPP implements the following:

- Detection of the straight lines that are defined by the parametric equation:
  \[ r = x \cos(\theta) + y \sin(\theta), \] where \( r \) and \( \theta \) are the length and angle from the origin of a normal to the line, respectively.
- Detection of lines using the probabilistic Hough transform algorithm [Matas00].

HoughLineGetSize

Computes the size of the working buffer for the straight lines detection.

Syntax

\[
\text{IppStatus ippiHoughLineGetSize}_\text{8u}_\text{C1R}(	ext{IppiSize roiSize}, \text{IppPointPolar delta}, \text{int maxLineCount}, \text{int* pBufSize});
\]

Include Files

ippi cv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- roiSize: Size of the source image ROI, in pixels.
- delta: Step of discretization (delta.rho - radial increment, delta.theta - angular increment).
- maxLineCount: Number of elements of the destination buffer.
- pBufSize: Pointer to the size of the working buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function computes the size of the temporary working buffer that is required for the function ippiHoughLine.

Return Values

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error if pBufSize is NULL.
- ippStsSizeErr: Indicates an error condition if roiSize or delta has a field with zero or negative value.
**HoughLine**

*Detects straight lines in the source image.*

**Syntax**

```c
IppStatus ippiHoughLine_8u32f_C1R(const Ipp8u* pSrc, int srcStep, IppiSize roiSize, IppPointPolar delta, int threshold, IppPointPolar* pLine, int maxLineCount, int* pLineCount, Ipp8u* pBuffer);
```

**Include Files**

ippcv.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**
  Pointer to the source image ROI.

- **srcStep**
  Distance in bytes between starts of consecutive lines in the source image.

- **roiSize**
  Size of source image ROI in pixels.

- **delta**
  Step of discretization (\(\Delta \rho\) - radial increment, \(\Delta \theta\) - angular increment).

- **threshold**
  Minimum number of points that are required to detect the line.

- **pLine**
  Pointer to the destination buffer for lines.

- **pLineCount**
  Number of detected lines. If the value is more than \(\text{maxLineCount}\), the function returns the ippStsDstSizeLessExpected status.

- **maxLineCount**
  Number of elements of the destination buffer.

- **pBuffer**
  Pointer to the working buffer.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

In the binarised source image \(\text{pSrc}\), the function performs detection of the straight line defined by the equation given at the beginning of section Hough Transform. The level of discretization \(\text{delta}\) is specified as the input parameters. The performance and effectiveness of the function is strongly depends on this parameter. The function requires the external working buffer \(\text{pBuffer}\), which size should be computed previously using the function ippiHoughLineGetSize.

**Caution**

The value of the parameter \(\text{delta}\) must not be greater than the value of the parameter \(\text{delta}\) set when the size of the working buffer is computed.
Return Values

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error if one of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error condition if roiSize has a field with zero or negative value; or if maxLineCount is less than or equal to 0.
- ippStsStepErr: Indicates an error condition if srcStep has an illegal value.
- ippStsBadArgErr: Indicates an error condition if threshold is less than or equal to 0; or delta.rho is less than 0, or greater than sum of the width and height of the ROI; or delta.theta is less than 0, or greater than p.
- ippStsDstSizeLessExpected: Indicates a warning if number of the detected lines is greater than the size of the destination buffer maxLineCount.

HoughLine_Region

Detects straight lines with the specified range of parameters in the source image.

Syntax

IppStatus ippiHoughLine_Region_8u32f_C1R(const Ipp8u* pSrc, int srcStep, IppiSize roiSize, IppPointPolar* pLine, IppPointPolar dstRoi[2], int maxLineCount, int* pLineCount, IppPointPolar delta, int threshold, Ipp8u* pBuffer);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- pSrc: Pointer to the source image ROI.
- srcStep: Distance in bytes between starts of consecutive lines in the source image.
- roiSize: Size of source image ROI, in pixels.
- pLine: Pointer to the destination array of detected lines.
- dstRoi: Specifies the range of parameters of straight lines to be detected.
- pLineCount: Pointer to the number of detected lines.
- delta: Step of discretization (delta.rho - radial increment, delta.theta - angular increment).
- threshold: Minimum number of points that are required to detect the line.
- maxLineCount: Maximum number of lines in the destination buffer.
- pBuffer: Pointer to the working buffer.
Description
This function operates with ROI (see Regions of Interest in Intel IPP).

In the binary source image \( pSrc \), this function performs detection of the straight line defined by the equation given at the beginning of section Hough Transform. Only lines \( \text{line}[n] \) with the parameters satisfying the following conditions are detected:

\[
\text{dstRoi}[0].\rho \leq \text{line}[n].\rho \leq \text{dstRoi}[1].\rho;
\]
\[
\text{dstRoi}[0].\theta \leq \text{line}[n].\theta \leq \text{dstRoi}[1].\theta;
\]

where \( n = 0 \). \( pLineCount \).

The level of discretization \( \delta \) is specified as the input parameters. The performance and effectiveness of the function is strongly depends on this parameter. The function requires the external working buffer \( pBuffer \), which size should be computed previously using the function \( \text{ippiHoughLineGetSize} \).

Caution
The value of the parameter \( \delta \) must not be greater than the value of the parameter \( \delta \) set when the size of the working buffer is computed.

Return Values

- \( \text{ippStsNoErr} \): Indicates no error.
- \( \text{ippStsNullPtrErr} \): Indicates an error if one of the specified pointers is NULL.
- \( \text{ippStsSizeErr} \): Indicates an error condition if \( \text{roiSize} \) has a field with zero or negative value; or if \( \text{maxLineCount} \) is less than or equal to 0.
- \( \text{ippStsStepErr} \): Indicates an error condition if \( \text{srcStep} \) has an illegal value.
- \( \text{ippStsBadArgErr} \): Indicates an error condition if \( \text{threshold} \) is less than or equal to 0; or \( \delta.rho \) is less than 0, or greater than sum of the width and height of the ROI; or \( \delta.theta \) is less than 0, or greater than \( p \); or some filed of \( \text{dstRoi}[0] \) is greater than the corresponding filed of \( \text{dstRoi}[1] \).
- \( \text{ippStsDstSizeLessExpected} \): Indicates a warning if number of the detected lines is greater than the size of the destination buffer \( \text{maxLineCount} \).

\text{HoughProbLineGetSize}
Computes the size of the working buffer and spec structure for line detection with the probabilistic Hough transform algorithm.

Syntax

\[
\text{IppStatus} \ \text{ippiHoughProbLineGetSize}_8u\_C1R(IppSize \text{roiSize}, \text{IppPointPolar} \delta, \text{int}^* \text{pSpecSize}, \text{int}^* \text{pBufSize});
\]

Include Files

- \( \text{ippcv.h} \)

Domain Dependencies

Headers: \( \text{ippcore.h}, \text{ippvm.h}, \text{ipps.h}, \text{ippi.h} \)

Libraries: \( \text{ippcore.lib}, \text{ippvm.lib}, \text{ipps.lib}, \text{ippi.lib} \)
Parameters

roiSize  
Size of the source image ROI, in pixels.

delta  
Step of discretization (delta.rho - radial increment, delta.theta - angular increment).

pSpecSize  
Size of the IppiHoughProbSpec structure.

pBufSize  
Pointer to the size of the working buffer.

Description

This function operates with ROI.

This function computes the size of the temporary working buffer and the IppiHoughProbSpec specification structure for the ippiHoughProbLine function.

For an example on how to use this function, see the example provided with the ippiHoughProbLine function description.

Return Values

ippStsNoErr  
Indicates no error.

ippStsNullPtrErr  
Indicates an error if pBufSize is NULL.

ippStsSizeErr  
Indicates an error condition if roiSize or delta has a field with a zero or negative value.

See Also

Regions of Interest in Intel IPP

HoughProbLine  Detects lines in the source image using the probabilistic Hough transform.

HoughProbLinelnit

*Initializes the specification structure for line detection with the probabilistic Hough transform algorithm.*

Syntax

IppStatus ippiHoughProbLinelnit_8u32f_C1R(IppiSize roiSize, IppPointPolar delta, IppHintAlgorithm hint, IppiHoughProbSpec* pSpec);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters

roiSize  
Size of the source image ROI, in pixels.

delta  
Step of discretization (delta.rho - radial increment, delta.theta - angular increment).
**Description**

This function operates with ROI.

This function initializes the `IppiHoughProbSpec` specification structure that is required for the `ippiHoughProbLine` function.

For an example on how to use this function, see the example provided with the `ippiHoughProbLine` function description.

**Return Values**

- `ippStsNoErr` Indicates no error.
- `ippStsNullPtrErr` Indicates an error if `pBufSize` is NULL.
- `ippStsSizeErr` Indicates an error condition if `roiSize` or `delta` has a field with zero or negative value.

**See Also**

- Regions of Interest in Intel IPP
- **HoughProbLine** Detects lines in the source image using the probabilistic Hough transform.

**Syntax**

```c
IppStatus ippiHoughProbLine_8u32f_C1R(const Ipp8u* pSrc, int srcStep, IppiSize roiSize, int threshold, int lineLength, int lineGap, IppiPoint* pLine, int maxLineCount, int* pLineCount, Ipp8u* pBuffer, const IppiHoughProbSpec* pSpec);
```

**Include Files**

`ippcv.h`

**Domain Dependencies**

- **Headers**: `ippcore.h, ippvm.h, ipps.h,ippi.h`
- **Libraries**: `ippcore.lib, ippvm.lib, ipps.lib,ippi.lib`

**Parameters**

- `pSrc` Pointer to the source image ROI.
- `srcStep` Distance, in bytes, between the starting points of consecutive lines in the source image.
- `roiSize` Size of the source image ROI in pixels.
- `threshold` Minimum number of points that are required to detect the line.
- `lineLength` Minimum length of the line.
- `lineGap` Maximum length of the gap between lines.
**pLine**  
Pointer to the detected line: \( pLine[2*n] \) indicates beginning of the line, \( pLine[2*n+1] \) indicates end of the line.

**pLineCount**  
Number of detected lines.

**maxLineCount**  
Number of elements in the destination buffer.

**pBuffer**  
Pointer to the working buffer.

**pSpec**  
Pointer to the specification structure.

**Description**

This function operates with ROI.

This function detects line segments of the binary \( pSrc \) image using the probabilistic Hough transform. Before using this function, compute the size of the working buffer and specification structure using the `ippiHoughProbGetSize` function and initialize the structure using the `ippiHoughProbLineInit` function.

This function implements the probabilistic Hough transform algorithm for line detection, described in [Matas00].

**Return Values**

- `ippStsNoErr`: Indicates no error.
- `ippStsNullPtrErr`: Indicates an error if one of the specified pointers is NULL.
- `ippStsSizeErr`: Indicates an error condition if `roiSize` has a field with zero or negative value; or if `maxLineCount` is less than or equal to 0.
- `ippStsStepErr`: Indicates an error condition if `srcStep` has an illegal value.
- `ippStsBadArgErr`: Indicates an error condition if `threshold` is less than or equal to 0.
- `ippStsDstSizeLessExpected`: Indicates a warning if number of the detected lines is greater than the size of the destination buffer `maxLineCount`.

**Example**

To better understand usage of the `ippiHoughProbLine` function, refer to the `HoughProbLine.c` example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

**See Also**

Regions of Interest in Intel IPP

- **HoughProbLineGetSize**: Computes the size of the working buffer and spec structure for line detection with the probabilistic Hough transform algorithm.
- **HoughProbLineInit**: Initializes the specification structure for line detection with the probabilistic Hough transform algorithm.

**LineSuppressionGetBufferSize**

*Computes the size of the external buffer for the
ippiLineSupression function.*

**Syntax**

```c
IppStatus ippLineSupressionGetBufferSize(IppiSize roiSize, IppiMaskSize filterMask, Ipp32u avgWndSize, IppDataType dataType, int numChannels, int* pBufferSize);
```
Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
roiSize  Size of the source and destination image ROI, in pixels.
filterMask  Size of the derivative filter aperture. Possible values are ippMskSize3x3 and ippMskSize5x5.
avgWndSize  Linear size of a neighborhood block for averaging.
dataType  Data type of the source image.
umChannels  Number of channels in the images. Possible value is 1.
pBufferSize  Pointer to the size, in bytes, of the external work buffer.

Description
This function calculates the size of the temporary buffer for the ippiLineSuppression function.

Return Values
ippStsNoErr  Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr  Indicates an error when pBufferSize is NULL.
ippStsSizeErr  Indicates an error in the following cases:
  • when roiSize is less than, or equal to zero
  • when avgWndSize is equal to zero
ippStsMaskSizeErr  Indicates an error when filterMask has an illegal value.
ippStsDataTypeErr  Indicates an error when dataType has an illegal value.
ippStsNumChannelsErr  Indicates an error when numChannels has an illegal value.

See Also
LineSuppression  Implements the line suppression algorithm.

LineSuppression
Implements the line suppression algorithm.

Syntax
IppStatus ippiLineSuppression_8u_C1R(const Ipp8u* pSrc, int srcStep, const Ipp8u* pFeature, int featureStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, IppiDifferentialKernel filterType, IppiMaskSize filterMask, Ipp32u avgWndSize, float threshold, IppiBorderType borderType, Ipp8u borderValue, Ipp8u* pBuffer);
Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc  Pointer to the source image.
srcStep  Distance, in bytes, between the starting points of consecutive lines in the source image.
pFeature  Pointer to the feature points image.
featureStep  Distance, in bytes, between the starting points of consecutive lines in the feature points image.
pDst  Pointer to the destination image.
dstStep  Distance, in bytes, between the starting points of consecutive lines in the destination image.
roiSize  Size of the source and destination image ROI, in pixels.
filterType  Type of the derivative operator. Possible values are:
ippKernelSobel  Sobel filter
ippKernelScharr  Scharr filter
ippKernelCentralDiff  Central differences operator

filterMask  Size of the derivative filter aperture. The list of possible values depends on the filterType value:

<table>
<thead>
<tr>
<th>Filter Type</th>
<th>Filter Mask</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippKernelSobel</td>
<td>ippMskSize3x3, ippMskSize5x5</td>
</tr>
<tr>
<td>ippKernelScharr</td>
<td>ippMskSize3x3</td>
</tr>
<tr>
<td>ippKernelCentralDiff</td>
<td>ippMskSize3x3</td>
</tr>
</tbody>
</table>

avgWndSize  Linear size of a neighborhood block for averaging.
threshold  Line suppression threshold.

borderType  Type of border. Possible values are:
ippBorderConst  Values of all border pixels are set to a constant.
ippBorderRepl  Border is replicated from the edge pixels.
ippBorderInMem  Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderRepl or ippBorderConst and the following flags:

• ippBorderInMemTop
Each of these flags means that for the corresponding border the outside pixels of the source image are in memory.

borderValue

Constant value(s) to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

pBuffer

Pointer to the work buffer. To calculate the size of the temporary buffer, use the LineSuppressionGetBufferSize function.

**Description**

The ippiLineSuppression function implements the line suppression algorithm. This function uses two input images: the original image and feature points image containing the lines (edges) and corners. This function performs the following steps:

1. Computes $I(x, y)_x$ and $I(x, y)_y$ gradients for each $(x, y)$ pixel of the image. The function computes gradients using the derivative operator specified by the filterType and filterMask parameters.

2. Computes products of the gradients at each $(x, y)$ pixel of the image:

   $$I(x, y)_x = I(x, y)_x \star I(x, y)_x, \quad I(x, y)_y = I(x, y)_y \star I(x, y)_y, \quad I(x, y) = I(x, y)_x \star I(x, y)_y$$

3. Performs averaging of the products of gradients over a rectangular neighborhood block at each pixel of the image. The block size is specified by the avgWndSize value.

   $$S_{xx}(x, y) = \sum_{y'} \sum_{x'} I(x', y'), \quad S_{xy}(x, y) = \sum_{y'} \sum_{x'} I(x', y'), \quad S_{yy}(x, y) = \sum_{y'} \sum_{x'} I(x', y')$$

4. Defines 2x2 gradient covariance matrix $H(x, y)$ over a rectangular neighborhood block for each $(x, y)$ pixel of the image.

   $$H(x, y) = \begin{pmatrix} S_{xx}(x, y) & S_{xy}(x, y) \\ S_{xy}(x, y) & S_{yy}(x, y) \end{pmatrix}$$

5. For each $(x, y)$ pixel of the image checks the condition below. If the condition is true, the considered point is not a feature point.

   $$\frac{(\lambda_1 + \lambda_2)^2}{\lambda_1 \lambda_2} = \frac{(trH(x, y))^2}{\det H(x, y)} > \text{threshold}$$

   where

   - **threshold** is the line suppression threshold value passed to the function
   - $\lambda_1 \lambda_2$ are eigenvalues of the matrix $H(x, y)$. If both eigenvalues have large positive values, the point belongs to a corner. If $\lambda_1$ is much bigger than $\lambda_2$, the function clears out the candidate point.

The first and third stages of the function algorithm are filtering operations; they use border processing approach that is specified by the borderType parameter.
Before using this function, compute the size of the external work buffer using the **LineSuppressionGetBufferSize** function.

### Return Values

- **ippiStsNoErr**
  - Indicates no error.

- **ippiStsNullPtrErr**
  - Indicates an error when `pSrc`, `pFeature`, `pDst`, or `pBufferSize` is NULL.

- **ippiStsSizeErr**
  - Indicates an error in the following cases:
    - when `roiSize` is less than, or equal to zero
    - when `avgWndSize` is equal to zero

- **ippiStsNotEvenStepErr**
  - Indicates an error when one of the step values is not divisible by 4 for floating point images.

- **ippiStsFilterTypeErr**
  - Indicates an error when `filterType` has an illegal value.

- **ippiStsMaskSizeErr**
  - Indicates an error when `filterMask` has an illegal value.

- **ippiStsBorderErr**
  - Indicates an error when `borderType` has an illegal value.

- **ippiStsStepErr**
  - Indicates an error when `srcStep` or `dstStep` has a negative value.

- **ippiStsInplaceModeNotSupportedErr**
  - Indicates an error when `pFeature` and `pDst` point to the same image.

### Example

To better understand usage of the **ippiLineSuppression** function, refer to the **LineSuppression.c** example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

### See Also

- **LineSuppressionGetBufferSize** Computes the size of the external buffer for the **ippiLineSuppression** function.

### Distance Transform Functions

This section describes the distance transform functions.

Distance transform is used for calculating the distance to an object. The input is an image with feature and non-feature pixels. The function labels every non-feature pixel in the output image with a distance to the closest feature pixel. Feature pixels are marked with zero.

Distance transform is used for a wide variety of subjects including skeleton finding and shape analysis.

**DistanceTransform**

*Calculates distance to the closest zero pixel for all non-zero pixels of source image.*

### Syntax

**Case 1: Not-in-place operations**

```c
IppStatus ippiDistanceTransform_3x3_<mod>(const Ipp8u* pSrc, int srcStep,
Ipp<dstDatatype>* pDst, int dstStep, IppiSize roiSize, Ipp32s* pMetrics);
```
IppStatus ippiDistanceTransform_5x5_<mod>(const Ipp8u* pSrc, int srcStep, Ipp<dstDatatype>* pDst, int dstStep, IppSize roiSize, Ipp32s* pMetrics);

Supported values for `mod`:

- 8u_C1R
- 8u16u_C1R

IppStatus ippiDistanceTransform_3x3_8u32f_C1R(const Ipp8u* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppSize roiSize, Ipp32f* pMetrics);

IppStatus ippiDistanceTransform_5x5_8u32f_C1R(const Ipp8u* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppSize roiSize, Ipp32f* pMetrics);

**Case 2: In-place operations**

IppStatus ippiDistanceTransform_3x3_8u_C1IR(Ipp8u* pSrcDst, int srcDstStep, IppSize roiSize, Ipp32s* pMetrics);

IppStatus ippiDistanceTransform_5x5_8u_C1IR(Ipp8u* pSrcDst, int srcDstStep, IppSize roiSize, Ipp32s* pMetrics);

**Include Files**

ippcv.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- `pSrc`: Pointer to the source image ROI.
- `srcStep`: Distance in bytes between starts of consecutive lines in the source image.
- `pDst`: Pointer to the ROI in the destination distance image.
- `dstStep`: Distance in bytes between starts of consecutive lines in the destination image.
- `pSrcDst`: Pointer to the source and destination image ROI for in-place operation.
- `srcDstStep`: Distance in bytes between starts of consecutive lines in the source and destination image for in-place operation.
- `roiSize`: Size of the image ROI in pixels.
- `pMetrics`: Pointer to the array that specifies used metrics.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function approximates the actual distance from the closest zero pixel to each certain pixel with the sum of atomic distances from the fixed set. The set consists of two values for a 3x3 mask and three values for a 5x5 mask.

**Figure “3x3 Mask”** shows the result of the distance transform of a 7x7 image with zero point in the center. This example corresponds to a 3x3 mask. Two numbers specify metrics in case of the 3x3 mask:

- distance between two pixels that share an edge,
• distance between the pixels that share a corner.

In this case the values are 1 and 1.5 correspondingly.

### 3x3 Mask

<table>
<thead>
<tr>
<th>4.5</th>
<th>4</th>
<th>3.5</th>
<th>3</th>
<th>3.5</th>
<th>4</th>
<th>4.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3</td>
<td>2.5</td>
<td>2</td>
<td>2.5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3.5</td>
<td>2.5</td>
<td>1.5</td>
<td>1</td>
<td>1.5</td>
<td>2.5</td>
<td>3.5</td>
</tr>
<tr>
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<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3.5</td>
<td>2.5</td>
<td>1.5</td>
<td>1</td>
<td>1.5</td>
<td>2.5</td>
<td>3.5</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>2.5</td>
<td>2</td>
<td>2.5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4.5</td>
<td>4</td>
<td>3.5</td>
<td>3</td>
<td>3.5</td>
<td>4</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Figure “5x5 Mask” shows the distance transform for the same image, but for a 5x5 mask.

For this mask yet another number is added to specify metrics - the additional distance, i.e., the distance between pixels corresponding to the chess knight move.

In this example, the additional distance is equal to 2.

### 5x5 Mask

<table>
<thead>
<tr>
<th>4</th>
<th>3.5</th>
<th>3</th>
<th>3</th>
<th>3</th>
<th>3.5</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3.5</td>
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<td>2</td>
<td>1.5</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3.5</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
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<td>3.5</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3.5</td>
<td>4</td>
</tr>
</tbody>
</table>

### Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if roiSize has a field with zero or negative value.
- **ippStsStepErr**: Indicates an error condition if srcStep or dstStep is less than roiSize.width*<pixelSize>.
- **ippStsNotEvenStepErr**: Indicates an error condition if step value is not divisible by 2 for 16u images, and by 4 for 32f images.
- **ippStsCoeffErr**: Indicates an error condition if at least one element of pMetrics array has zero or negative value.

### Example

To better understand usage of the *ippiDistanceTransform* function, refer to the *DistanceTransform.c* example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

Result:

```
1 2 3 4 5 6 7
1 0 3 4 5 6 7
1 2 3 4 5 6 7
1 2 3 0 5 6 7
```

GetDistanceTransformMask
Returns an optimal mask for a given type of metrics and given mask size.

Syntax
IppStatus ippiGetDistanceTransformMask_<mod>(int kerSize, IppiNorm norm, Ipp<datatype>* pMetrics);

Supported values for mod:

32s 32f

IppStatus ippiGetDistanceTransformMask(int maskType, Ipp32f* pMetrics);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
kerSize

Specifies the mask size as follows: 3 for 3x3 mask, 5 for 5x5 mask.

norm

Specifies the type of metrics. Possible values are:

ippiNormInf(0)  L_\infty, \Delta = \max(|x_1 - x_2|, |y_1 - y_2|),
ippiNormL1(1)   L_1, \Delta = |x_1 - x_2| + |y_1 - y_2|,
ippiNormL2(2)   L_2, \Delta = \sqrt((x_1 - x_2)^2 + (y_1 - y_2)^2)

maskType

Distance type.

pMetrics

Pointer to the output array to store metrics parameters. The array contains the following number of elements:

2  for 3x3 mask,
3  for 5x5 mask.
Description
This function fills up the output array with metrics parameters for the given type of metrics and size of mask. The function returns the following results:

- \((1, 1)\) \(L_\infty\), 3x3 mask,
- \((1, 2)\) \(L_1\), 3x3 mask,
- \((2, 3)\) \(L_2\), 3x3 mask, 32s data type,
- \((0.955, 1.3693)\) \(L_2\), 3x3 mask, 32f data type,
- \((1, 1, 2)\) \(L_\infty\), 5x5 mask,
- \((1, 2, 3)\) \(L_1\), 5x5 mask,
- \((4, 6, 9)\) \(L_2\), 5x5 mask, 32s data type,
- \((1.0, 1.4, 2.1969)\) \(L_2\), 5x5 mask, 32f data type.

For more information, see [Bor86].

NOTE
For compatibility with the previous versions of the library the earlier function ippiGetDistanceTransformMask replaced by the function ippiGetDistanceTransformMask_32f in the current version is also supported.

Return Values
- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error condition if pMetrics pointer is NULL.
- ippStsSizeErr: Indicates an error condition if kerSize has a wrong value.
- ippStsBadArgErr: Indicates an error condition if kerSize or norm has a wrong value.

FastMarchingGetBufferSize
Computes the size of the working buffer for the peak search.

Syntax
IppStatus ippiFastMarchingGetBufferSize_8u32f_C1R(IppiSize roiSize, int* pBufferSize);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib
Parameters

**roiSize**
Maximum image size (in pixels).

**pBufferSize**
Pointer to the computed size of the buffer.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function computes the size of the working buffer required for the ippiFastMarching function. The buffer with the length \( pBufferSize[0] \) can be used to filter images with width that is equal to or less than the parameter \( roiSize \) specified for the function ippiFastMarching.

Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error or a warning.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error condition if ( pBufferSize ) pointer is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error condition if ( roiSize ) is less than 1.</td>
</tr>
</tbody>
</table>

FastMarching
*Calculates distance transform to closest zero pixel for all non-zero pixels of source image using fast marching method.*

Syntax

```c
IppStatus ippiFastMarching_8u32f_C1R(const Ipp8u* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, Ipp32f radius, Ipp8u* pBuffer);
```

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pSrc</td>
<td>Pointer to the source image ROI.</td>
</tr>
<tr>
<td>srcStep</td>
<td>Distance in bytes between starts of consecutive lines in the source image.</td>
</tr>
<tr>
<td>pDst</td>
<td>Pointer to the destination image ROI.</td>
</tr>
<tr>
<td>dstStep</td>
<td>Distance in bytes between starts of consecutive lines in the destination image.</td>
</tr>
<tr>
<td>roiSize</td>
<td>Size of the source and destination image ROI.</td>
</tr>
<tr>
<td>radius</td>
<td>Radius of the neighborhood of the marked area.</td>
</tr>
<tr>
<td>pBuffer</td>
<td>Pointer to the working buffer.</td>
</tr>
</tbody>
</table>
Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function computes the distance from the closest zero pixel to each image pixel according to the Fast Marching Method (FMM) [Telea04]. The FMM distance for area Ω with the border ∂Ω is a solution of the equations:

\[
|∇ T(x, y)| = 1, \ \{x, y\} \in \ Ω
\]

\[
T(x, y) = 0, \ \{x, y\} \in \partial \ Ω
\]

The resulting distance complies with the equation

\[
T(x, y) = \min \left( \frac{T(u_1, v_1) + T(u_2, v_2) + \sqrt{2 - (T(u_1, v_1) - T(u_2, v_2))^2}}{2}, \min(T(u_1, v_1), T(u_2, v_2)) + 1 \right)
\]

Here \(\{u_1, v_1\}\) and \(\{u_2, v_2\}\) are coordinates for pair of pixels adjacent to the pixel with \(\{x, y\}\) coordinates.

The area \(\Omega\) is defined by the non-zero pixel of the image \(pSrc\). If \(radius\) is positive, then the FMM distance with the negative sign is calculated in Euclidean \(radius\)-neighborhood of \(\Omega\).

The function requires the working buffer \(pBuffer\) whose size should be computed by the function \(FastMarchingGetBufferSize\) beforehand.

Figure "Result of the FMM Method" shows the result of the fast marching method for the 7x9 image with centered 3x5 non-zero mask and \(radius=1\).

Result of the FMM Method

<p>| | | | | | | | | |</p>
<table>
<thead>
<tr>
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<td>-1.0000</td>
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<td>-1.e-10</td>
<td>-1.e-10</td>
<td>-1.e-10</td>
<td>0.7071</td>
<td>-1.0000</td>
</tr>
<tr>
<td>-1.0000</td>
<td>-1.e-10</td>
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<td>0.9659</td>
<td>0.9994</td>
<td>0.9659</td>
<td>0.7071</td>
<td>-1.e-10</td>
<td>-1.0000</td>
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<td>0.9659</td>
<td>0.9994</td>
<td>0.9659</td>
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<td>-1.0000</td>
</tr>
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<td>0.0000</td>
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<td>-1.e-10</td>
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<td>-1.0000</td>
<td>-1.0000</td>
<td>-1.0000</td>
<td>0.0000</td>
<td>0.0000</td>
</tr>
</tbody>
</table>

Return Values

ippStsNoErr
 Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr
 Indicates an error condition if one of the specified pointers is NULL.

ippStsSizeErr
 Indicates an error condition if roiSize has a field with zero or negative value.

ippStsStepErr
 Indicates an error condition if srcStep or dstStep is less than roiSize.width * <pixelSize>.

ippStsNotEvenStepErr
 Indicates an error condition if the step value is not divisible by 4 for floating-point images.

ippStsBadArgErr
 Indicates an error condition if radius is negative.
**TrueDistanceTransformGetBufSize**  
*Calculates the size of the temporary working buffer for the function ippiTrueDistanceTransform.*

**Syntax**

```c
IppStatus ippiTrueDistanceTransformGetBufferSize_8u32f_C1R(IppiSize roiSize, int* pBufferSize);
```

**Include Files**
ippcv.h

**Domain Dependencies**

- **Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h
- **Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- `roiSize` : Size of the image ROI in pixels.
- `pBufferSize` : Pointer to the computed size of the buffer.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).  
This function calculates the size of the work buffer required for the TrueDistanceTransform function.

**Return Values**

- `ippStsNoErr` : Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr` : Indicates an error condition if one of the specified pointers is NULL.
- `ippStsSizeErr` : Indicates an error condition if `roiSize` has a field with zero or negative value.
- `ippStsStepErr` : Indicates an error condition if `srcStep` or `dstStep` is less than `roiSize.width*<pixelSize>`.
- `ippStsNotEvenStepErr` : Indicates an error condition if step value is not divisible by 2 for 16u images, and by 4 for 32f images.

**TrueDistanceTransform**  
*Calculates the Euclidean distance to the closest zero pixel for all non-zero pixels of the source image.*

**Syntax**

```c
IppStatus ippiTrueDistanceTransform_8u32f_C1R(const Ipp8u* pSrc, int srcStep, Ipp32f* pDst, int dstStep, IppiSize roiSize, Ipp8u* pBuffer);
```

**Include Files**
ippcv.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the ROI in the destination distance image.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**: Size of the image ROI in pixels.
- **pBuffer**: Pointer to the temporary working buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function calculates the Euclidean distance to the closest zero pixel for all non-zero pixels of the source image [Felz04].

The figure below shows the result of the integer version of the true distance transform of a 7x7 image with zero point in the center and with the scale factor -5.

<table>
<thead>
<tr>
<th>136</th>
<th>115</th>
<th>101</th>
<th>96</th>
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<td>136</td>
<td>115</td>
<td>101</td>
<td>96</td>
<td>101</td>
<td>115</td>
<td>136</td>
</tr>
</tbody>
</table>

Return Values

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error condition if one of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error condition if roiSize has a field with zero or negative value.
- ippStsStepErr: Indicates an error condition if srcStep or dstStep is less than roiSize.width*<pixelSize>.
- ippStsNotEvenStepErr: Indicates an error condition if step value is not divisible by 2 for 16u images, and by 4 for 32f images.

Image Gradients
**GradientColorToGray**  
*Converts a color gradient image to grayscale.*

**Syntax**

```c
IppStatus ippiGradientColorToGray_<mod>(const Ippdatatype* pSrc, int srcStep, Ippdatatype* pDst, int dstStep, IppSize roiSize, IppiNorm norm);
```

Supported values for `mod`:

- 8u_C3C1R
- 16u_C3C1R
- 32f_C3C1R

**Include Files**

ippcv.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h, ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

**Parameters**

- `pSrc`  
  Pointer to the source image ROI.

- `srcStep`  
  Distance in bytes between starts of consecutive lines in the source image.

- `pDst`  
  Pointer to the destination image ROI.

- `dstStep`  
  Distance in bytes between starts of consecutive lines in the destination image.

- `roiSize`  
  Size of the source and destination image ROI.

- `norm`  
  Type of norm to form the mask for dilation; following values are possible:
  - ippiNormInf  
    Infinity norm.
  - ippiNormL1  
    L1 norm.
  - ippiNormL2  
    L2 norm.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function creates the grayscale gradient image `pDst` from the source three-channel gradient image `pSrc`. The type of norm is specified by the parameter. Pixel values for destination image are computed for different type of norm in accordance with the following formula:

\[
dst_{i, j} = \begin{cases} 
\max\{|src_{i, 0}|, |src_{i, 1}|, |src_{i, 2}|\} & \text{norm = ippiNormInf} \\
|src_{i, 0}| + |src_{i, 1}| + |src_{i, 2}| & \text{norm = ippiNormL1} \\
\sqrt{src_{i, 0}^2 + src_{i, 1}^2 + src_{i, 2}^2} & \text{norm = ippiNormL2}
\end{cases}
\]

For integer flavors the result is scaled to the full range of the destination data type.
Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if `roiSize` has a field with zero or negative value.
- **ippStsStepErr**: Indicates an error condition if `srcStep` or `dstStep` is less than `roiSize.width * <pixelSize>`.
- **ippStsNotEvenStepErr**: Indicates an error condition if one of the step values is not divisible by 2 for integer images, or by 4 for floating-point images.
- **ippStsBadArgErr**: Indicates an error condition if `norm` has an illegal value.

**GradientVectorGetBufferSize**

*Computes the size of the work buffer for the ippGradientVector{Sobel|Scharr|Prewitt} functions.*

**Syntax**

```c
IppStatus ippiGradientVectorGetBufferSize (IppiSize roiSize, IppiMaskSize mask, IppDataType dataType, int numChannels, int* pBufferSize);
```

**Include Files**

ippi.h

**Domain Dependencies**

- **Headers**: ippcore.h, ippvm.h, ipps.h
- **Libraries**: ippcore.lib, ippvm.lib, ipps.lib

**Parameters**

- **roiSize**: Size of the destination ROI in pixels.
- **mask**: Predefined mask of IppiMaskSize type.
- **dataType**: Data type of the source image.
- **numChannels**: Number of channels in the image.
- **pBufferSize**: Pointer to the computed size of the external work buffer.

**Description**

The ippiGradientVectorGetBufferSize function computes the size (in bytes) of the external work buffer needed for the ippiGradientVector{Sobel|Scharr|Prewitt} functions and stores the result in the pBufferSize parameter.
Return Values

ippStsNoErr  Indicates no error.
ippStsNullPtrErr  Indicates an error when pBufferSize is NULL.
ippStsSizeErr  Indicates an error when one of the fields of roiSize has a zero or negative value.
ippStsMaskSizeErr  Indicates an error when mask has an illegal value.
ippStsDataTypeErr  Indicates an error when dataType has an illegal value.
ippStsNumChannelsErr  Indicates an error when numChannels has an illegal value.

See Also
Structures and Enumerators
GradientVectorPrewitt  Computes gradient vectors of an image using the Prewitt operator.
GradientVectorScharr  Computes gradient vectors of an image using the Scharr operator.
GradientVectorSobel  Computes gradient vectors of an image using the Sobel operator.

GradientVectorPrewitt

*Computes gradient vectors of an image using the Prewitt operator.*

Syntax

IppStatus ippiGradientVectorPrewitt_<mod> (const Ipp<srcDatatype>* pSrc, int srcStep,
Ipp<dstDatatype>* pGx, int gxStep, Ipp<dstDatatype>* pGy, int gyStep, Ipp<dstDatatype>*
pMag, int magStep, Ipp32f* pAngle, int angleStep, IppiSize dstRoiSize, IppiMaskSize
maskSize, IppNormType normType, IppiBorderType borderType, Ipp<srcDatatype>
borderValue, Ipp8u* pBuffer);

Supported values for mod:

8u16s_C1R 16s32f_C1R 16u32f_C1R 32f_C1R

IppStatus ippiGradientVectorPrewitt_<mod> (const Ipp<srcDatatype>* pSrc, int srcStep,
Ipp<dstDatatype>* pGx, int gxStep, Ipp<dstDatatype>* pGy, int gyStep, Ipp<dstDatatype>*
pMag, int magStep, Ipp32f* pAngle, int angleStep, IppiSize dstRoiSize, IppiMaskSize
maskSize, IppNormType normType, IppiBorderType borderType, const Ipp<srcDatatype>
borderValue[3], Ipp8u* pBuffer);

Supported values for mod:

8u16s_C3C1R 16s32f_C3C1R 16u32f_C3C1R 32f_C3C1R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

pSrc  
Pointer to the source image ROI.

srcStep  
Distance, in bytes, between the starting points of consecutive lines in the source image.

pGx  
Pointer to the destination image ROI for the X component of the gradient vector (in Cartesian form).

gxStep  
Distance, in bytes, between the starting points of consecutive lines in the X-component destination image.

pGy  
Pointer to the destination image ROI for the Y component of the gradient vector (in Cartesian form).

gyStep  
Distance, in bytes, between the starting points of consecutive lines in the Y-component destination image.

pMag  
Pointer to the magnitude of the gradient destination image ROI (in polar gradient form).

magStep  
Distance, in bytes, between the starting points of consecutive lines in the magnitude of the gradient destination image.

pAngle  
Pointer to the destination image ROI for the angle (in polar gradient form).

angleStep  
Distance, in bytes, between the starting points of consecutive lines in the angle destination image.

dstRoiSize  
Size of the source and destination image ROI in pixels.

maskSize  
Predefined mask of IppiMaskSize type.

normType  
Normalization mode of IppNormType type.

borderType  
Type of border. Possible values are:

ippBorderConst  
Values of all border pixels are set to constant.

ippBorderRepl  
Border is replicated from the edge pixels.

ippBorderInMem  
Border is obtained from the source image pixels in memory.

ippBorderMirror  
Border pixels are mirrored from the source image boundary pixels.

borderValue  
Constant value to assign to pixels in the constant border (not applicable for other border types).

pBuffer  
Pointer to the work buffer.
Description

This function operates with ROI (see Regions of Interest in Intel IPP).

Before using this function, compute the size of the work buffer using the ippiGradientVectorGetBufferSize function.

NOTE

Any of the pGx, pGy, pMag, and pAngle output parameters can be NULL. This means that the parameter(s) is not requested.

This function operates on "gray" single-channel (C1 flavors) and color (C3 flavors) images.

Single-channel image (C1) input:

If input is a single-channel image, the ippiGradientVectorPrewitt function computes the gradient vector at each pixel of the source image ROI and stores the result either in Cartesian (pGx and pGy) and/or polar (pMag and pAngle) form, or any combination of these possible outputs.

Cartesian projections G_x and G_y are stored in the pGx and pGy buffers, respectively. The formulas below describe the algorithm for the 3x3 Prewitt operator:

\[
G_x = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix} * A \quad \text{and} \quad G_y = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 0 & 0 \\ -1 & -1 & -1 \end{bmatrix} * A
\]

where

- A is the source image
- * means two-dimensional convolution
- G_x and G_y are X and Y components of the gradient

The magnitude of the gradient is computed according to the normType value by the following formulas:

L1 normalization:

\[
G = |G_x| + |G_y|
\]

L2 normalization:

\[
G = \sqrt{G_x^2 + G_y^2}
\]

The value of angle between G_x and G_y is computed by the formula:

\[
\text{angle} = \arctan \frac{G_y}{G_x}
\]

Color image (C3) input:
If input is a color image, the `ippiGradientVectorPrewitt` function computes the spatial image derivatives $G_x$ and $G_y$ for each channel of the image using the specified differential operator. For each pixel $(x, y)$ this function chooses the derivatives for which $L2(G_x, G_y)$ is the maximal value and stores them in the $pGx$ and $pGy$ output arrays. In other words, for each pixel of a color image the function returns the derivatives composing the largest gradient across all channels.

The examples of using this function are similar to the examples provided with the `GradientVectorSobel` function description.

**Return Values**

- **ippStsNoErr** Indicates no error.
- **ippStsNullPtrErr** Indicates an error when `pSrc` or `pBuffer` is NULL.
- **ippStsSizeErr** Indicates an error when one of the fields of `dstRoiSize` has a zero or negative value.
- **ippStsMaskSizeErr** Indicates an error when `maskSize` has an illegal value.
- **ippStsStepErr** Indicates an error when:
  - `srcStep`, `gxStep`, `gyStep`, `magStep`, or `angleStep` has a zero or negative value
  - `srcStep`, `gxStep`, `gyStep`, `magStep`, or `angleStep` is not a multiple of the image data size (4 for floating-point images or 2 for short integer images)
- **ippStsBadArgErr** Indicates an error when `normType` has an illegal value.
- **ippStsBorderErr** Indicates an error when `borderType` has an incorrect value.

**See Also**

- **Structures and Enumerators**
- **Regions of Interest in Intel IPP**

**GradientVectorGetBufferSize** Computes the size of the work buffer for the `ippiGradientVector{Sobel|Scharr|Prewitt}` functions.

**GradientVectorScharr**

*Computes gradient vectors of an image using the Scharr operator.*

**Syntax**

```c
IppStatus ippiGradientVectorScharr_<mod> (const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pGx, int gxStep, Ipp<dstDatatype>* pGy, int gyStep, Ipp<dstDatatype>* pMag, int magStep, Ipp32f* pAngle, int angleStep, IppSize dstRoiSize, IppiMaskSize maskSize, IppNormType normType, IppiBorderType borderType, Ipp<srcDatatype> borderValue, Ipp8u* pBuffer);
```

Supported values for `mod`:

- `8u16s_C1R`  `16s32f_C1R`  `16u32f_C1R`  `32f_C1R`
IppStatus ippiGradientVectorScharr_<mod> (const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pGx, int gxStep, Ipp<dstDatatype>* pGy, int gyStep, Ipp<dstDatatype>* pMag, int magStep, Ipp32f* pAngle, int angleStep, IppiSize dstRoiSize, IppiMaskSize maskSize, IppNormType normType, IppiBorderType borderType, const Ipp<srcDatatype> borderValue[3], Ipp8u* pBuffer); 

Supported values for mod: 
8u16s_C3C1R 16s32f_C3C1R 16u32f_C3C1R 32f_C3C1R

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc
Pointer to the source image ROI.

srcStep
Distance, in bytes, between the starting points of consecutive lines in the source image.

pGx
Pointer to the destination image ROI for the X component of the gradient vector (in Cartesian form).

gxStep
Distance, in bytes, between the starting points of consecutive lines in the X-component destination image.

pGy
Pointer to the destination image ROI for the Y component of the gradient vector (in Cartesian form).

gyStep
Distance, in bytes, between the starting points of consecutive lines in the Y-component destination image.

pMag
Pointer to the magnitude of the gradient destination image ROI (in polar gradient form).

magStep
Distance, in bytes, between the starting points of consecutive lines in the magnitude of the gradient destination image.

pAngle
Pointer to the destination image ROI for the angle (in polar gradient form).

angleStep
Distance, in bytes, between the starting points of consecutive lines in the angle destination image.

dstRoiSize
Size of the source and destination image ROI in pixels.

maskSize
Predefined mask of IppiMaskSize type.

normType
Normalization mode of IppNormType type.
**borderType**

Type of border. Possible values are:

- ippBorderConst: Values of all border pixels are set to constant.
- ippBorderRepl: Border is replicated from the edge pixels.
- ippBorderInMem: Border is obtained from the source image pixels in memory.
- ippBorderMirror: Border pixels are mirrored from the source image boundary pixels.

**borderValue**

Constant value to assign to pixels in the constant border (not applicable for other border types).

**pBuffer**

Pointer to the work buffer.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

Before using this function, compute the size of the work buffer using the ippiGradientVectorGetBufferSize function.

---

**NOTE**

Any of the pGx, pGy, pMag, and pAngle output parameters can be NULL. This means that the parameter(s) is not requested.

This function operates on "gray" single-channel (C1 flavors) and color (C3 flavors) images.

**Single-channel image (C1) input**

If input is a single-channel image, the ippiGradientVectorScharr function computes the gradient vector at each pixel of the source image ROI and stores the result either in Cartesian (pGx and pGy) and/or polar (pMag and pAngle) form, or any combination of these possible outputs.

Cartesian projections Gx and Gy are stored in the pGx and pGy buffers, respectively. The formulas below describe the algorithm for the 3x3 Scharr operator:

\[
G_x = \begin{bmatrix} 3 & 0 & -3 \\ 10 & 0 & -10 \\ 3 & 0 & -3 \end{bmatrix} * A \\
G_y = \begin{bmatrix} 3 & 10 & 3 \\ 0 & 0 & 0 \\ -3 & -10 & -3 \end{bmatrix} * A
\]

where

- A is the source image
- * means two-dimensional convolution
- Gx and Gy are X and Y components of the gradient

The magnitude of the gradient is computed according to the normType value by the following formulas:

L1 normalization:
L2 normalization:

\[ G = \sqrt{G_x^2 + G_y^2} \]

The value of angle between \( G_x \) and \( G_y \) is computed by the formula:

\[ \text{angle} = \arctan \frac{G_y}{G_x} \]

**Color image (C3) input:**

If input is a color image, the `ippiGradientVectorScharr` function computes the spatial image derivatives \( G_x \) and \( G_y \) for each channel of the image using the specified differential operator. For each pixel \((x, y)\) this function chooses the derivatives for which \( L2(G_x, G_y) \) is the maximal value and stores them in the \( pGx \) and \( pGy \) output arrays. In other words, for each pixel of a color image the function returns the derivatives composing the largest gradient across all channels.

The examples of using this function are similar to the examples provided with the `GradientVectorSobel` function description.

**Return Values**

- `ippStsNoErr`: Indicates no error.
- `ippStsNullPtrErr`: Indicates an error when \( pSrc \) or \( pBuffer \) is NULL.
- `ippStsSizeErr`: Indicates an error when one of the fields of \( dstRoiSize \) has a zero or negative value.
- `ippStsMaskSizeErr`: Indicates an error when \( maskSize \) has an illegal value.
- `ippStsStepErr`: Indicates an error when:
  - \( srcStep, gxStep, gyStep, magStep, \) or \( angleStep \) has a zero or negative value
  - \( srcStep, gxStep, gyStep, magStep, \) or \( angleStep \) is not a multiple of the image data size (4 for floating-point images or 2 for short integer images)
- `ippStsBadArgErr`: Indicates an error when \( normType \) has an illegal value.
- `ippStsBorderErr`: Indicates an error when \( borderType \) has an incorrect value.

**See Also**

- **Structures and Enumerators**
- **Regions of Interest in Intel IPP**
- `GradientVectorGetBufferSize`: Computes the size of the work buffer for the `ippiGradientVector{Sobel|Scharr|Prewitt}` functions.
GradientVectorSobel

Computes gradient vectors of an image using the Sobel operator.

Syntax

IppStatus ippiGradientVectorSobel_<mod> (const Ipp<srcDatatype>* pSrc, int srcStep, Ipp<dstDatatype>* pGx, int gxStep, Ipp<dstDatatype>* pGy, int gyStep, Ipp<dstDatatype>* pMag, int magStep, Ipp32f* pAngle, int angleStep, IppiSize dstRoiSize, IppiMaskSize maskSize, IppNormType normType, IppiBorderType borderType, Ipp<srcDatatype> borderValue, Ipp8u* pBuffer);

Supported values for mod:

8u16s_C1R 16s32f_C1R 16u32f_C1R 32f_C1R

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc

Pointer to the source image ROI.

dstStep

Distance, in bytes, between the starting points of consecutive lines in the source image.

pGx

Pointer to the destination image ROI for the X component of the gradient vector (in Cartesian form).

gxStep

Distance, in bytes, between the starting points of consecutive lines in the X-component destination image.

pGy

Pointer to the destination image ROI for the Y component of the gradient vector (in Cartesian form).

gyStep

Distance, in bytes, between the starting points of consecutive lines in the Y-component destination image.
**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

Before using this function, compute the size of the work buffer using the GradientVectorGetBufferSize function.

**NOTE**

Any of the `pGx`, `pGy`, `pMag`, and `pAngle` output parameters can be NULL. This means that the parameter(s) is not requested.

This function operates on "gray" single-channel (C1 flavors) and color (C3 flavors) images.

**Single-channel image (C1) input :**

If input is a single-channel image, the `ippiGradientVectorSobel` function computes the gradient vector at each pixel of the source image ROI and stores the result either in Cartesian (`pGx` and `pGy`) and/or polar (`pMag` and `pAngle`) form, or any combination of these possible outputs.
Cartesian projections $G_x$ and $G_y$ are stored in the $pGx$ and $p Gy$ buffers, respectively. The formulas below describe the algorithm for the 3x3 Sobel operator:

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} * A \quad G_y = \begin{bmatrix} 1 & 2 & 1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix} * A$$

for the 5x5 Sobel operator:

$$G_x = \begin{bmatrix} -1 & -2 & 0 & 2 & 1 \\ -4 & -8 & 0 & 8 & 4 \\ -6 & -12 & 0 & 12 & 6 \\ -4 & -8 & 0 & 8 & 4 \\ -1 & -2 & 0 & 2 & 1 \end{bmatrix} * A \quad G_y = \begin{bmatrix} 1 & 4 & 6 & 4 & 1 \\ 0 & 8 & 12 & 8 & 2 \\ 2 & 0 & 0 & 0 & 0 \\ -2 & -8 & -12 & -8 & -2 \\ -1 & -4 & -6 & -4 & -1 \end{bmatrix} * A$$

where

- $A$ is the source image
- * means two-dimensional convolution
- $G_x$ and $G_y$ are X and Y components of the gradient

The magnitude of the gradient is computed according to the `normType` value by the following formulas:

**L1 normalization:**

$$G = |G_x| + |G_y|$$

**L2 normalization:**

$$G = \sqrt{G_x^2 + G_y^2}$$

The value of angle between $G_x$ and $G_y$ is computed by the formula:

$$angle = \arctan \frac{G_y}{G_x}$$

*Color image (C3) input:*
If input is a color image, the `ippiGradientVectorSobel` function computes the spatial image derivatives $G_x$ and $G_y$ for each channel of the image using the specified differential operator. For each pixel $(x, y)$ this function chooses the derivatives for which $L^2(G_x, G_y)$ is the maximal value and stores them in the $pGx$ and $pGy$ output arrays. In other words, for each pixel of a color image the function returns the derivatives composing the largest gradient across all channels.

**Return Values**

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error when `pSrc` or `pBuffer` is NULL.
- **ippStsSizeErr**: Indicates an error when one of the fields of `dstRoiSize` has a zero or negative value.
- **ippStsMaskSizeErr**: Indicates an error when `maskSize` has an illegal value.
- **ippStsStepErr**: Indicates an error when:
  - `srcStep`, `gxStep`, `gyStep`, `magStep`, or `angleStep` has a zero or negative value
  - `srcStep`, `gxStep`, `gyStep`, `magStep`, or `angleStep` is not a multiple of the image data size (4 for floating-point images or 2 for short integer images)
- **ippStsBadArgErr**: Indicates an error when `normType` has an illegal value.
- **ippStsBorderErr**: Indicates an error when `borderType` has an incorrect value.

**Example**

To better understand usage of the `ippiGradientVectorSobel` function, refer to the `GradientVectorSobel1.c` and `GradientVectorSobel2.c` examples in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

**See Also**

- Structures and Enumerators
- Regions of Interest in Intel IPP
- GradientVectorGetBufferSize: Computes the size of the work buffer for the `ippiGradientVector{Sobel|Schar|Prewitt}` functions.

**Flood Fill Functions**

This section describes functions performing flood filling of connected areas. **Flood filling** means that a group of connected pixels with close values is filled with, or is set to, a certain value. The flood filling process starts with a specified point ("seed") and continues until it reaches the image ROI boundary or cannot find any new pixels to fill due to a large difference in pixel values. For every pixel filled, the functions analyze neighbor pixels:

- 4 neighbors (except diagonal neighbors); this kind of connectivity is called 4-connectivity and the corresponding function name includes `4Con`, or
• 8 neighbors (diagonal neighbors included); this kind of connectivity is called 8-connectivity and the corresponding function name includes 8Con.

Pixels Connectivity Patterns

These functions can be used for:
• segmenting a grayscale image into a set of uni-color areas,
• marking each connected component with individual color for bi-level images.

FloodFillGetSize
Calculates size of temporary buffer for flood filling operation.

Syntax
IppStatus ippiFloodFillGetSize(IppiSize roiSize, int* pBufSize);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
roiSize Size of the source image ROI in pixels.
pBufSize Pointer to the variable that returns the size of the temporary buffer.

Description
This function calculates the size of the temporary buffer to be used by the function ippiFloodFill.

Return Values
ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error condition if pBufSize pointer is NULL.
ippStsSizeErr Indicates an error condition if roiSize has a field with zero or negative value.
**FloodFillGetSize_Grad**  
*Calculates size of temporary buffer for the gradient flood filling.*

**Syntax**

```c
IppStatus ippiFloodFillGetSize_Grad(IppiSize roiSize, int* pBufSize);
```

**Include Files**

ippcv.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h  
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- `roiSize`: Size of the source image ROI in pixels.
- `pBufSize`: Pointer to the variable that returns the size of the temporary buffer.

**Description**

This function calculates the size of the temporary buffer to be used by the function `ippiFloodFill_Grad`.

**Return Values**

- `ippStsNoErr`: Indicates no error. Any other value indicates an error or a warning.
- `ippStsNullPtrErr`: Indicates an error condition if `pBufSize` pointer is NULL.
- `ippStsSizeErr`: Indicates an error condition if `roiSize` has a field with zero or negative value.

**FloodFill**  
*Performs flood filling of connected area.*

**Syntax**

**Case 1: Operations on one-channel data**

```c
IppStatus ippiFloodFill_4Con_<mod>(Ipp<datatype>* pImage, int imageStep, IppiSize roiSize, IppiPoint seed, Ipp<datatype> newVal, IppiConnectedComp* pRegion, Ipp8u* pBuffer);
```

```c
IppStatus ippiFloodFill_8Con_<mod>(Ipp<DataType>* pImage, int imageStep, IppiSize roiSize, IppiPoint seed, Ipp<datatype> newVal, IppiConnectedComp* pRegion, Ipp8u* pBuffer);
```

Supported values for `mod`:

- 8u_C1IR
- 16u_C1IR
- 32s_C1IR
- 32f_C1IR
Case 2: Operations on three-channel data

IppStatus ippiFloodFill_4Con_<mod>(Ipp<datatype>* pImage, int imageStep, IppiSize roiSize, IppiPoint seed, Ipp<datatype>* pNewVal, IppiConnectedComp* pRegion, Ipp8u* pBuffer);
IppStatus ippiFloodFill_8Con_<mod>(Ipp<DataType>* pImage, int imageStep, IppiSize roiSize, IppiPoint seed, Ipp<datatype>* pNewVal, IppiConnectedComp* pRegion, Ipp8u* pBuffer);

Supported values for mod:

8u_C3IR  16u_C3IR  32f_C3IR

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pImage  Pointer to the ROI in the source and destination image (for the inplace operation).
imageStep  Distance in bytes between starts of consecutive lines in the image buffer.
roiSize  Size of the image ROI in pixels.
seed  Initial point.
newVal  Value to fill with for one-channel data.
pNewVal  Pointer to the vector containing values to fill with for three-channel data.
pRegion  Pointer to the connected components structure that stores information about the refilled area.
pBuffer  Pointer to the temporary buffer.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function performs flood filling (see Flood Filling Functions) of the group of connected pixels whose pixel values are equal to the value in the seed point. Values of these pixel is set to the newVal value.
The function requires a temporary buffer whose size should be computed with the function ippiFloodFillGetSize beforehand.
The functions with the "_4con" suffixes check 4-connected neighborhood of each pixel, that is, side neighbors. The functions with the "_8con" suffixes check 8-connected neighborhood of each pixel, that is, side and corner neighbors. See Figure Pixels Connectivity Patterns.

Return Values

ippStsNoErr  Indicates no error. Any other value indicates an error or a warning.
Indicates an error condition if one of the specified pointers is NULL.

Indicates an error condition if roiSize has a field with zero or negative value.

Indicates an error condition if imageStep is less than roiSize.width*pixelSize.

Indicates an error condition if steps for floating-point images are not divisible by 4, or steps for 16-bit integer images are not divisible by 2.

Indicates an error condition if the seed point is out of ROI.

Example
To better understand usage of theippiFloodFill function, refer to the FloodFill.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

FloodFill_Grad
Performs gradient flood filling of connected area on an image.

Syntax
Case 1: Operations on one-channel data

IppStatusippiFloodFill_Grad4Con_<mod>(Ipp<DataType>* pImage, int imageStep, IppiSize roiSize, IppiPoint seed, Ipp<datatype> newVal, Ipp<datatype> minDelta, Ipp<datatype> maxDelta, IppiConnectedComp* pRegion, Ipp8u* pBuffer);

IppStatusippiFloodFill_Grad8Con_<mod>(Ipp<DataType>* pImage, int imageStep, IppiSize roiSize, IppiPoint seed, Ipp<datatype> newVal, Ipp<datatype> minDelta, Ipp<datatype> maxDelta, IppiConnectedComp* pRegion, Ipp8u* pBuffer);

Supported values for mod:

8u_C1IR 16u_C1IR 32f_C1IR

Case 2: Operations on three-channel data

IppStatusippiFloodFill_Grad4Con_<mod>(Ipp<DataType>* pImage, int imageStep, IppiSize roiSize, IppiPoint seed, Ipp<datatype>* pNewVal, Ipp<datatype>* pMinDelta, Ipp<datatype>* pMaxDelta, IppiConnectedComp* pRegion, Ipp8u* pBuffer);

IppStatusippiFloodFill_Grad8Con_<mod>(Ipp<DataType>* pImage, int imageStep, IppiSize roiSize, IppiPoint seed, Ipp<datatype>* pNewVal, Ipp<datatype>* pMinDelta, Ipp<datatype>* pMaxDelta, IppiConnectedComp* pRegion, Ipp8u* pBuffer);

Supported values for mod:

8u_C3IR 16u_C3IR 32f_C3IR

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
**Parameters**

*pImage*

Pointer to the ROI in the source and destination image (in-place operation).

*imageStep*

Distance in bytes between starts of consecutive lines in the image buffer.

*roiSize*

Size of the image ROI in pixels.

*seed*

Initial point.

*minDelta*

Minimum difference between neighbor pixels for one-channel data.

*maxDelta*

Maximum difference between neighbor pixels for one-channel data.

*newVal*

Value to fill with for one-channel data.

*pMinDelta*

Pointer to the minimum differences between neighbor pixels for three-channel images.

*pMaxDelta*

Pointer to the maximum differences between neighbor pixels for three-channel images.

*pNewVal*

Pointer to the vector containing values to fill with for three-channel data.

*pRegion*

Pointer to the connected components structure that stores information about the refilled area.

*pBuffer*

Pointer to the temporary buffer.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function performs flood filling (see Flood Filling Functions) of the group of connected pixels in the *seed* pixel neighborhoods whose pixel values *v* satisfy the following conditions:

\[ v_0 - d_{iw} s_{i} v_s s_{r} v_{r} + d_{up}, \]

where *v*₀ is the value of at least one of the current pixel neighbors, which already belongs to the refilled area, and *d*₁₁, *d*₁₂ are *minDelta*, *maxDelta*, respectively. Values of these pixels are set to the *newVal* value.

The function requires a temporary buffer whose size should be computed with the function `ippiFloodFillGetSize_Grad` beforehand.

The functions with the "_4con" suffixes check 4-connected neighborhood of each pixel, i.e., side neighbors. The functions with the "_8con" suffixes check 8-connected neighborhood of each pixel, i.e., side and corner neighbors. See Figure Pixels Connectivity Patterns.

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**
  Indicates an error condition if one of the specified pointers is NULL.

- **ippStsSizeErr**
  Indicates an error condition if *roiSize* has a field with zero or negative value.

- **ippStsStepErr**
  Indicates an error condition if *imageStep* is less than *pRoiSize.width*<pixelSize>.
Indicates an error condition if steps for floating-point images are not divisible by 4, or steps for 16-bit integer images are not divisible by 2.

Indicates an error condition if the seed point is out of ROI.

**Example**

To better understand usage of the `ippiFloodFill_Grad` function, refer to the `FloodFill_Grad.c` example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

**FloodFill_Range**

*Performs flood filling of pixels with values in the specified range in the connected area on an image.*

**Syntax**

**Case 1: Operations on one-channel data**

```
IppStatus ippiFloodFill_Range4Con_<mod>(Ipp<DataType>* pImage, int imageStep, IppiSize roiSize, IppiPoint seed, Ipp<datatype> newVal, Ipp<datatype> minDelta, Ipp<datatype> maxDelta, IppiConnectedComp* pRegion, Ipp8u* pBuffer);
IppStatus ippiFloodFill_Range8Con_<mod>(Ipp<DataType>* pImage, int imageStep, IppiSize roiSize, IppiPoint seed, Ipp<datatype> newVal, Ipp<datatype> minDelta, Ipp<datatype> maxDelta, IppiConnectedComp* pRegion, Ipp8u* pBuffer);
```

Supported values for `mod`:

```
8u_C1IR  16u_C1IR  32f_C1IR
```

**Case 2: Operations on three-channel data**

```
IppStatus ippiFloodFill_Range4Con_<mod>(Ipp<DataType>* pImage, int imageStep, IppiSize roiSize, IppiPoint seed, Ipp<datatype>* pNewVal, Ipp<datatype> pMinDelta, Ipp<datatype> pMaxDelta, IppiConnectedComp* pRegion, Ipp8u* pBuffer);
IppStatus ippiFloodFill_Range8Con_<mod>(Ipp<DataType>* pImage, int imageStep, IppiSize roiSize, IppiPoint seed, Ipp<datatype>* pNewVal, Ipp<datatype> pMinDelta, Ipp<datatype> pMaxDelta, IppiConnectedComp* pRegion, Ipp8u* pBuffer);
```

Supported values for `mod`:

```
8u_C3IR  16u_C3IR  32f_C3IR
```

**Include Files**

`ippcv.h`

**Domain Dependencies**

**Headers:** `ippcore.h`, `ippvm.h`, `ipps.h`, `ippi.h`

**Libraries:** `ippcore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`
Parameters

- **pImage**: Pointer to the ROI in the source and destination image (in-place operation).
- **imageStep**: Distance in bytes between starts of consecutive lines in the image buffer.
- **roiSize**: Size of the image ROI in pixels.
- **seed**: Initial point.
- **minDelta**: Minimum difference between neighbor pixels for one-channel data.
- **maxDelta**: Maximum difference between neighbor pixels for one-channel data.
- **newVal**: Value to fill with for one-channel data.
- **pMinDelta**: Pointer to the minimum differences between neighbor pixels for three-channel images.
- **pMaxDelta**: Pointer to the maximum differences between neighbor pixels for three-channel images.
- **pNewVal**: Pointer to the vector containing values to fill with for three-channel data.
- **pRegion**: Pointer to the connected components structure that stores information about the refilled area.
- ** pBuffer**: Pointer to the temporary buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function performs **flood filling** (see Flood Filling Functions) of the group of connected pixels in the seed pixel neighborhoods whose pixel values $v$ satisfy the following conditions:

$$v_0 - d_{lw} \leq v \leq v_0 + d_{up},$$

where $v_0$ is the pixel value of the seed point, and $d_{lw}$, $d_{up}$ are **minDelta**, **maxDelta**, respectively. Values of these pixels are set to the **newVal** value.

The function requires a temporary buffer whose size should be computed with the function **ippiFloodFillGetSize_Grad** beforehand.

The functions with the "_4con" suffixes check 4-connected neighborhood of each pixel, i.e., side neighbors. The functions with the "_8con" suffixes check 8-connected neighborhood of each pixel, i.e., side and corner neighbors. See Figure Pixels Connectivity Patterns”.

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if **roiSize** has a field with zero or negative value.
- **ippStsStepErr**: Indicates an error condition if **imageStep** is less than **pRoiSize.width** * <pixelSize>. 
Motion Analysis and Object Tracking

**FGMMGetBufferSize**
*Computes the size of the state structure for the Gaussian mixture model foreground/background subtraction.*

**Syntax**
```c
IppStatus ippiFGMMGetBufferSize_8u_C3R(IppiSize roi, int maxNGauss, int* pSpecSize);
```

**Include Files**
ippcv.h

**Domain Dependencies**
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **roi**
  Size of the source image ROI, in pixels.
- **maxNGauss**
  Maximal size of the Gaussian mixture components.
- **pSpecSize**
  Pointer to the size of the IppFGMMSpec_8u_C3R structure.

**Description**
This function operates with ROI.
This function computes the size of the IppFGMMSpec_8u_C3R structure for the FGMMForeground and FGMMBackground functions.

**Return Values**

- **ippStsNoErr**
  Indicates no error.
- **ippStsNullPtrErr**
  Indicates an error when pSpecSize is NULL.
- **ippStsSizeErr**
  Indicates an error when roi is less than, or equal to zero.
- **ippStsBadArgErr**
  Indicates an error when maxNumGauss is less than, or equal to zero.

**See Also**
Regions of Interest in Intel IPP
FGMMForeground  Performs the Gaussian mixture model foreground subtraction.
FGMMBackground  Returns the updated background image.
**FGMMInit**

*Initializes the state structure for the Gaussian mixture model foreground/background subtraction.*

**Syntax**

```c
IppStatus ippiFGMMInit_8u_C3R(IppiSize roi, int maxNGauss, IppFGMModel* pModel, IppFGMMState_8u_C3R* pState);
```

**Include Files**

`ippcv.h`

**Domain Dependencies**

*Headers:* `ippcore.h`, `ippvm.h`, `ipps.h`, `ippi.h`

*Libraries:* `ippcore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`

**Parameters**

- `roi`  
  Size of the source image ROI, in pixels.

- `maxNGauss`  
  Maximal size of the Gaussian mixture components.

- `pModel`  
  Pointer to the `IppFGMModel` structure containing parameters for the model. If `pModel` is `NULL`, the default parameters are applied.

- `pState`  
  Pointer to the `IppFGMMState_8u_C3R` state structure.

**Description**

This function operates with ROI.

This function initializes the `IppFGMMState_8u_C3R` state structure for the `FGMMForeground` and `FGMMBackground` functions.

Before using this function, you need to compute the size of the state structure using the `FGMMGetBufferSize` function.

**Return Values**

- `ippStsNoErr`  
  Indicates no error.

- `ippStsNullPtrErr`  
  Indicates an error when `pModel` or `pState` is `NULL`.

- `ippStsSizeErr`  
  Indicates an error when `roi` is less than, or equal to zero.

- `ippStsBadArgErr`  
  Indicates an error when `maxNGauss` is less than, or equal to zero.

**See Also**

- **Regions of Interest in Intel IPP**
- **FGMMForeground**  
  Performs the Gaussian mixture model foreground subtraction.
- **FGMMBackground**  
  Returns the updated background image.
- **FGMMGetBufferSize**  
  Computes the size of the state structure for the Gaussian mixture model foreground/background subtraction.
**FGMMForeground**  
*Performs the Gaussian mixture model foreground subtraction.*

**Syntax**

```c
IppStatusippiFGMMForeground_8u_C3R(constIpp8upSrc, int srcStep, Ipp8upDst, int dstStep, IppiSize roi, IppFGMMState_8u_C3R*pState, IppFGMModel*pModel, double learning_rate);
```

**Include Files**

`ippcv.h`

**Domain Dependencies**

*Headers:* `ippcore.h`, `ippvm.h`, `ipps.h`, `ippi.h`  
*Libraries:* `ippcore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`

**Parameters**

- `pSrc`: Pointer to the source image.  
- `srcStep`: Distance, in bytes, between the starting points of consecutive lines in the source image.  
- `pDst`: Pointer to the one-channel `Ipp8u` mask of foreground.  
- `dstStep`: Distance, in bytes, between the starting points of consecutive lines in the destination image.  
- `roi`: Size of the source image ROI, in pixels.  
- `learning_rate`: Speed of algorithm learning.  
- `pState`: Pointer to the `IppFGMMState_8u_C3R` state structure.  
- `pModel`: Pointer to the `IppFGMModel` structure containing parameters for the model. If `pModel` is `NULL`, the parameters are the same as in a previous call.

**Description**

This function operates with ROI.  
This function implements the Gaussian mixture model foreground subtraction described in [ZIVKOVIC04]. The foreground mask is stored in `pDst`.  
Before using this function, you need to compute the size of the `IppFGMMState_8u_C3R` state structure and initialize the structure using the `FGMMGetBufferSize` and `FGMMInit` functions, respectively.  
For an example on how to use this function, refer to the example provided with the `FGMMBackground` function description.

**Return Values**

- `ippStsNoErr`: Indicates no error.  
- `ippStsNullPtrErr`: Indicates an error when `pSrc`, `pDst`, `pModel`, or `pState` is `NULL`.  
- `ippStsSizeErr`: Indicates an error when `roi` is less than, or equal to zero.
Indicates an error when srcStep or dstStep is less than, or equal to zero.

See Also
Regions of Interest in Intel IPP
FGMMGetBufferSize  Computes the size of the state structure for the Gaussian mixture model foreground/background subtraction.
FGMMInit  Initializes the state structure for the Gaussian mixture model foreground/background subtraction.
FGMMBackground  Returns the updated background image.

FGMMBackground

Syntax

IppStatus ippiFGMMBackground_8u_C3R(Ipp8u* pDst, int dstStep, IppiSize roi, IppFGMMState_8u_C3R* pState);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pDst  
Pointer to the three-channel background image.

dstStep  
Distance, in bytes, between the starting points of consecutive lines in the destination image.

roi  
Size of the source image ROI, in pixels.

pState  
Pointer to the IppFGMMState_8u_C3R state structure.

Description

This function implements the Gaussian mixture model background subtraction described in [ZIVKOVIC04]. The function returns the three-channel Ipp8u background image.

Before using this function, you need to compute the size of the IppFGMMState_8u_C3R state structure and initialize the structure using the FGMMGetBufferSize and FGMMInit functions, respectively.

Return Values

ippStsNoErr  
Indicates no error.

ippStsNullPtrErr  
Indicates an error when pDst or pState is NULL.

ippStsSizeErr  
Indicates an error when roi is less than, or equal to zero.

ippStsStepErr  
Indicates an error when dstStep is less than, or equal to zero.
Example

To better understand usage of the `ippiFGMMBackground` function, refer to the `FGMMBackground.c` example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

See Also
Regions of Interest in Intel IPP
FGMMGetBufferSize  Computes the size of the state structure for the Gaussian mixture model foreground/background subtraction.
FGMMInit  Initializes the state structure for the Gaussian mixture model foreground/background subtraction.

Motion Template Functions

This section describes a motion templates function. This function generates motion templates images to rapidly determine where, how, and in which direction the motion occurred. The algorithms are based on [Davis97], and [Davis99]. The function operates on images that are the output of frame or background differencing, or other image segmentation operations. Thus, the input and output image types are all grayscale, that is, one color channel. The pixel types can be 8u, 8s, or 32f.

Motion Representation

Figure Motion Image History” (a) shows capturing a foreground silhouette of the moving object or person. As the person or object moves, copying the most recent foreground silhouette as the highest values in the motion history image creates a “layered history” of the resulting motion. Typically, this “highest value” is just a floating-point timestamp of time since the code has been running in milliseconds. Figure Motion Image History” (b) shows the result that may be called the Motion History Image (MHI). The MHI in Figure Motion Image History” represents how the motion took place. A pixel level or a time delta threshold, as appropriate, is set such that pixel values in the MHI that fall below that threshold are set to zero.

Motion Image History

The most recent motion has the highest value, earlier motions have decreasing values subject to a threshold below which the value is set to zero.
Updating MHI Images

Generally, floating point images are used because system time differences, that is, time elapsing since the application was launched, are read in milliseconds to be further converted into a floating point number which is the value of the most recent silhouette. Then follows writing this current silhouette over the past silhouettes with subsequent thresholding away pixels that are too old to create the MHI.

UpdateMotionHistory

Updates motion history image using motion silhouette at given timestamp.

Syntax

IppStatus ippiUpdateMotionHistory_<mod>(const Ipp<srcDatatype>* pSilhouette, int silhStep, Ipp32f* pMhi, int mhiStep, IppiSize roiSize, Ipp32f timeStamp, Ipp32f mhiDuration);

Supported values for mod:

8u32f_C1IR 16u32f_C1IR 32f_C1IR

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSilhouette

Pointer to the silhouette image ROI that has non-zero values for those pixels where the motion occurs.

roiSize

Size of the image ROI in pixels.

silhStep

Distance in bytes between starts of consecutive lines in the silhouette image.

pMhi

Pointer to the motion history image which is both an input and output parameter.

mhiStep

Distance in bytes between starts of consecutive lines in the motion history image.

timeStamp

Timestamp in milliseconds.

mhiDuration

Threshold for MHI pixels. MHI motions older than this threshold are deleted.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function updates the motion history image. It sets MHI pixels to the current timestamp value, if their values are non-zero.

The function deletes MHI pixels, if their values are less than the mhiDuration timestamp, that is, the pixels are “old.”
Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error condition if one of the specified pointers is NULL.
ippStsSizeErr Indicates an error condition if roiSize has a field with zero or negative value.
ippStsStepErr Indicates an error condition if mhiStep or silhStep is less than roiSize.width * <pixelSize>.
ippStsNotEvenStepErr Indicates an error condition if the step value is not divisible by 2 for 16u images, and by 4 for 32f images.
ippStsOutOfRangeErr Indicates an error when mhiDuration is negative.

Optical Flow
This section describes the functions that calculate the optical flow using the pyramidal Lucas-Kanade algorithm [Bou99].
The optical flow between two images is generally defined as an apparent motion of image brightness. Let \( I(x, y, t) \) be the image brightness that changes in time to provide an image sequence.

Optical flow coordinates

\[
\begin{align*}
u &= \frac{\partial x}{\partial t}, \\
v &= \frac{\partial y}{\partial t}
\end{align*}
\]

can be found from so called optical flow constraint equation:

\[
-\frac{\partial I}{\partial t} = \frac{\partial I}{\partial x} u + \frac{\partial I}{\partial y} v
\]

The Lucas-Kanade algorithm assumes that the group of adjacent pixels has the same velocity and founds the approximate solution of the above equation using the least square method.

OpticalFlowPyrLKGetSize

Computes the size of the pyramidal optical flow state structure.

Syntax

\[
\text{IppStatus ippiOpticalFlowPyrLKGetSize(int winSize, IppiSize roiSize, IppDataType dataType, IppHintAlgorithm hint, int* pStateSize)};\]

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

\( \text{winSize} \) Size of the search window of each pyramid level.
roiSize

Maximal size of the source image (zero level of the pyramid) ROI, in pixels.

dataType

Data type of the image. Possible values: ipp8u, ipp16u, or ipp32f.

hint

Option to select the algorithmic implementation of the transform function.

pStateSize

Pointer to the size of the state structure.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function computes the size of the pState structure that is required to calculate the optical flow between two images in the centered window of size winSize*winSize using the pyramidal Lucas-Kanade [Bou99] algorithm. The hint argument specifies the computation algorithm. The pState structure is used by the ippiOpticalFlowPyrLK function and can be applied to process images with size not greater than roiSize.

Return Values

ippStsNoErr

Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr

Indicates an error when pStateSize is NULL.

ippStsDataTypeErr

Indicates an error when dataType has an illegal value.

ippStsSizeErr

Indicates an error when roiSize has a field with a zero or negative value; or when winSize is less than, or equal to zero.

See Also

Regions of Interest in Intel IPP
OpticalFlowPyrLK  Calculates optical flow for the set of feature points using the pyramidal Lucas-Kanade algorithm.
OpticalFlowPyrLKInit  Initializes the state structure for optical flow calculation.

OpticalFlowPyrLKInit

Initializes the state structure for optical flow calculation.

Syntax

IppStatus ippiOpticalFlowPyrLKInit_<mod>(IppiOptFlowPyrLK_<mod>** ppState, IppiSize roiSize, int winSize, IppHintAlgorithm hint, Ipp8u* pStateBuf);

Supported values for mod:

8u_C1R  16u_C1R  32f_C1R

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Parameters

- **ppState**: Double pointer to the optical flow state structure to be initialized.
- **roiSize**: Maximal size of the source image (zero level of the pyramid) ROI, in pixels.
- **winSize**: Size of the search window of each pyramid level.
- **hint**: Option to select the algorithmic implementation of the transform function.
- **pStateBuf**: Pointer to the work buffer for the state structure.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function initializes the `ppState` structure that is required to calculate the optical flow between two images in the centered window of size `winSize*winSize` using the pyramidal Lucas-Kanade [Bou99] algorithm. The `hint` argument specifies the computation algorithm. The `ppState` structure is used by the `ippiOpticalFlowPyrLK` function and can be applied to process images with size not greater than `roiSize`.

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when `ppState` is NULL.
- **ippStsSizeErr**: Indicates an error when `roiSize` has a field with a zero or negative value; or when `winSize` is less than, or equal to zero.

See Also

- Regions of Interest in Intel IPP
- **OpticalFlowPyrLK**  Calculates optical flow for the set of feature points using the pyramidal Lucas-Kanade algorithm.
- **OpticalFlowPyrLKGetSize**  Computes the size of the pyramidal optical flow state structure.

**OpticalFlowPyrLK**

*Calculates optical flow for the set of feature points using the pyramidal Lucas-Kanade algorithm.*

Syntax

```c
IppStatus ippiOpticalFlowPyrLK_<mod>(IppiPyramid* pPyr1, IppiPyramid* pPyr2, const IppiPoint_32f* pPrev, IppiPoint_32f* pNext, Ipp8s* pStatus, Ipp32f* pError, int numFeat, int winSize, int maxLev, int maxIter, Ipp32f threshold, IppiOptFlowPyrLK_<mod>* pState);
```

Supported values for `mod`:

- 8u_C1R
- 16u_C1R
- 32f_C1R

Include Files

- ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Parameters

- `pPyr1`: Pointer to the ROI in the first image pyramid structure.
- `pPyr2`: Pointer to the ROI in the second image pyramid structure.
- `pPrev`: Pointer to the array of initial coordinates of the feature points.
- `pNext`: Pointer to the array of new coordinates of feature point; as input it contains hints for new coordinates.
- `pStatus`: Pointer to the array of result indicators.
- `pError`: Pointer to the array of differences between neighborhoods of old and new point positions.
- `numFeat`: Number of feature points.
- `winSize`: Size of the search window of each pyramid level.
- `maxLev`: Pyramid level to start the operation.
- `maxIter`: Maximum number of algorithm iterations for each pyramid level.
- `threshold`: Threshold value.
- `pState`: Pointer to the pyramidal optical flow structure.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function implements the iterative version of the Lucas-Kanade algorithms [Bou99]. It computes with sub-pixel accuracy new coordinates of the `numFeat` feature points of two images at time $t$ and $t+dt$. Their initial coordinates are places in the `pPrev` array. Computed values of new coordinates of the feature points are stored in the array `pNext`, that initially contains estimations of them (or hints), for example, based on the flow values for the previous image in sequence. If there are not such hints, the `pNext` array contains the same initial coordinates as the `pPrev` array.

`pStatus` and `pError` are arrays of size `numFeat` with the respective data type.

The images are presented by the pyramid structures `pPyr1` and `pPyr2` respectively (see description of the `PyramidGetSize` and `ippiPyramidInit` functions for more details). These structures should be initialized by calling the function `PyramidGetSize` and `ippiPyramidInit` functions beforehand. The function uses the pyramidal optical flow structure `pState` that also should be previously initialized using `OpticalFlowPyrLKGetSize` and `OpticalFlowPyrLKInit`.

The function starts operation on the highest pyramid level (smallest image) that is specified by the `maxLev` parameter in the centered search window which size `winSize` could not exceed the corresponding value `winSize` that is specified in `OpticalFlowPyrLKGetSize` and `OpticalFlowPyrLKInit`. The operation for $i$-th feature point on the given pyramid level finishes if:

- New position of the point is found:
  $$\sqrt{dx^2 + dy^2} < \text{threshold}$$
- Specified number of iteration `maxIter` is performed
- Intersection between the pyramid layer and the search window became empty
In first two cases for non-zero levels the new position coordinates are scaled to the next pyramid level and the operation continues on the next level. For zero level or for third case the operation stops, the number of the corresponding level is written to the \( p_{\text{status}}[i] \) element, the new coordinates are scaled to zero level and are written to \( p_{\text{next}}[i] \). The square root of the average squared difference between neighborhoods of old and new positions is written to \( p_{\text{error}}[i] \).

**Return Values**

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error if one of the specified pointer is \( \text{NULL} \).
- **ippStsSizeErr**: Indicates an error condition if \( \text{numFeat} \) or \( \text{winSize} \) has zero or negative value.
- **ippStsBadArgErr**: Indicates an error condition if \( \text{maxLev} \) or \( \text{threshold} \) has negative value, or \( \text{maxIter} \) has zero or negative value.

**Example**

To better understand usage of the \( \text{ippiOpticalFlowPyrLK} \) function, refer to the \( \text{OpticalFlowPyrLK.c} \) example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

**Universal Pyramids**

The functions described in this section operate with universal image pyramids. These pyramids use separable symmetric kernel (not only Gaussian type) and downsampling/upsampling with arbitrary factor (not only 2). The next pyramid layer can be built for an image of an arbitrary size. These pyramids are used in some computer vision algorithms, for example, in optical flow calculations.

**NOTE**

All universal pyramid functions use the mirrored border.

**Example**  shows how to build pyramids and calculate the optical flow for two images.

**PyramidGetSize**

*Computes the size of the pyramid structure and the size of the temporary buffer for the \( \text{ippiPyramidInit} \) function.*

**Syntax**

\[
\text{IppStatus ippiPyramidGetSize(int* pPyrSize, int* pBufSize, int level, IppiSize roiSize, Ipp32f rate);}
\]

**Include Files**

ippcv.h

**Domain Dependencies**

- **Headers**: ippcore.h, ippvm.h, ipps.h,ippi.h
- **Libraries**: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Parameters

- **pPyrSize**: Pointer to the size of the pyramid structure.
- **pBufSize**: Pointer to the size of the external work buffer for pyramid processing.
- **level**: Maximum value for the pyramid level.
- **roiSize**: Size of zero level image ROI, in pixels.
- **rate**: Ratio between neighbouring levels (1 < rate ≤ 10).

Description

This function computes the size of the pyramid structure and the size of the temporary buffer, in bytes, for the `ippiPyramidInit` function. For an example on how to use this function, refer to the example provided with the `ippiPyramidLayerDown` function description.

Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error when any of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error when `roiSize` has a field with a zero or negative value.
- **ippStsBadArgErr**: Indicates an error when `level` is equal to or less than 0, or when `rate` is out of the range.

See Also

- **PyramidInit**: Initializes the pyramid structure and calculates the ROI size for pyramid layers.
- **PyramidLayerDown**: Creates a lower pyramid layer.

PyramidInit

*Initializes the pyramid structure and calculates the ROI size for pyramid layers.*

Syntax

```c
IppStatus ippiPyramidInit(IppiPyramid** pPyr, int level, IippiSize roiSize, Ipp32f rate,
Ipp8u* pPyrBuffer, Ipp8u* pBuffer);
```

Include Files

- `ippcv.h`

Domain Dependencies

- **Headers**: `ippcore.h`, `ippvm.h`, `ipps.h`, `ippi.h`
- **Libraries**: `ippcore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`

Parameters

- **pPyr**: Pointer to the pointer to the pyramid structure.
- **level**: Maximum value for the pyramid level.
- **roiSize**: Size of zero level image ROI, in pixels.
rate

Ratio between neighbouring levels (1 < rate ≤ 10).

pPyrBuffer

Pointer to the buffer for the pyramid structure initialization.

pBuffer

Pointer to the work buffer.

Description

This function initializes the structure for pyramid with (level+1) levels. This structure is used by the ippiOpticalFlowPyrLK function for optical flow calculation. The IppiPyramid structure contains the following fields:

- **pImage**: Pointer to the array of (level+1) layer images.
- **pStep**: Pointer to the array of (level+1) image row step values.
- **pRoi**: Pointer to the array of (level+1) layer image ROIs.
- **pRate**: Pointer to the array of (level+1) ratios of i-th levels to the zero level (rate^{-i}).
- **pState**: Pointer to the structure to compute the next pyramid layer.
- **level**: Number of levels in the pyramid.

The ippiPyramidInit function fills the pRoi and pRate arrays and the level field. The value of the level field is equal to the minimum of the input value of the level parameter and the maximum possible number of layers of the pyramid with given rate and zero level size.

You need to specify other fields. To initialize the pyramid layer structure pState, use the ippiPyramidLayerDownInit or ippiPyramidLayerUpInit functions. To obtain the pyramid layer images, you can use the ippiPyramidLayerDown and ippiPyramidLayerUp functions.

For an example on how to use this function, refer to the example provided with the ippiPyramidLayerDown function description.

Return Values

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error when at least one of the pointers is NULL.
- ippStsSizeErr: Indicates an error when roiSize has a field with a zero or negative value.
- ippStsBadArgErr: Indicates an error when level is equal to or less than 0, or when rate is out of the range.

See Also

- OpticalFlowPyrLK: Calculates optical flow for the set of feature points using the pyramidal Lucas-Kanade algorithm.
- PyramidLayerDownInit: Initializes the structure for creating a lower pyramid layer.
- PyramidLayerUpInit: Initializes the structure for creating an upper pyramid layer.
- PyramidLayerDown: Creates a lower pyramid layer.
- PyramidLayerUp: Creates an upper pyramid layer.

GetPyramidDownROI

*Computes the size of the lower pyramid layer.*
Syntax

IppStatus ippiGetPyramidDownROI(IppiSize srcRoiSize, IppiSize* pDstRoiSize, Ipp32f rate);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

- **srcRoiSize**: Size of the source pyramid layer ROI in pixels.
- **pDstRoiSize**: Pointer to the size of the destination (lower) pyramid layer ROI in pixels.
- **rate**: Ratio between source and destination layers (1 < rate ≤ 10).

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function computes the size of the lower pyramid layer pDstRoiSize for a source layer of a given size srcRoiSize and specified size ratio rate between them in accordance with the following formulas:

\[
\begin{align*}
pDstRoiSize.width & = \max(1, \min(\frac{\text{srcRoiSize.width}}{\text{rate}}, \text{srcRoiSize.width}-1)) \\
pDstRoiSize.height & = \max(1, \min(\frac{\text{srcRoiSize.height}}{\text{rate}}, \text{srcRoiSize.height}-1))
\end{align*}
\]

**NOTE**

Since for the non-integer rate results depend on the computational precision, it is strongly recommended to use this function in computations.

Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error if pDstRoiSize pointer is NULL.
- **ippStsSizeErr**: Indicates an error condition if srcRoiSize has a field with zero or negative value.
- **ippStsBadArgErr**: Indicates an error condition if rate is out of the range.

GetPyramidUpROI

*Computes the size of the upper pyramid layer.*

Syntax

IppStatus ippiGetPyramidUpROI(IppiSize srcRoiSize, IppiSize* pDstRoiSizeMin, IppiSize* pDstRoiSizeMax, Ipp32f rate);
Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

srcRoiSize
Size of the source pyramid layer ROI in pixels.

pDstRoiSizeMin
Pointer to the minimal size of the destination (upper) pyramid layer
ROI in pixels.

pDstRoiSizeMax
Pointer to the maximal size of the destination (upper) pyramid layer
ROI in pixels.

rate
Ratio between source and destination layers (1 < rate ≤ 10).

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function computes possible sizes of the upper pyramid layer pDstRoiSizeMin and pDstRoiSizeMax for
a source layer of a given size srcRoiSize and specified size ratio rate between them in accordance with the
following formulas:

maximum size pDstRoiSizeMax:

\[
p_{\text{DstRoiMax}}.width = \max(\text{srcRoiSize}.width + 1, \lfloor \text{srcRoiSize}.width \cdot \text{rate} \rfloor)
p_{\text{DstRoiMax}}.height = \max(\text{srcRoiSize}.height + 1, \lfloor \text{srcRoiSize}.height \cdot \text{rate} \rfloor)
\]

minimum size pDstRoiSizeMin:

if the width and height of the source layer ROI is greater than 1,

\[
p_{\text{DstRoiMin}}.width = \max(\text{srcRoiSize}.width + 1, \lfloor (\text{srcRoiSize}.width - 1) \cdot \text{rate} \rfloor)
p_{\text{DstRoiMin}}.height = \max(\text{srcRoiSize}.height + 1, \lfloor (\text{srcRoiSize}.height - 1) \cdot \text{rate} \rfloor)
\]

if the width and height of the source layer ROI is equal to 1,

\[
p_{\text{DstRoiMin}}.width = 1
p_{\text{DstRoiMin}}.height = 1
\]

NOTE
Since for the non-integer rate results depend on the computational precision, it is strongly
recommended to use this function in computations.

Return Values

ippStsNoErr
Indicates no error.

ippStsNullPtrErr
Indicates an error if one of the specified pointers is NULL.

ippStsSizeErr
Indicates an error condition if srcRoiSize has a field with zero or negative value.

ippStsBadArgErr
Indicates an error condition if rate is out of the range.
PyramidLayerDownGetSize

Computes the size of the structure for creating a lower pyramid layer and the size of the temporary buffer.

Syntax

IppStatus ippiPyramidLayerDownGetSize_8u_C1R(IppiSize srcRoi, Ipp32f rate, int kerSize, int* pStateSize, int* pBufSize);
IppStatus ippiPyramidLayerDownGetSize_8u_C3R(IppiSize srcRoi, Ipp32f rate, int kerSize, int* pStateSize, int* pBufSize);
IppStatus ippiPyramidLayerDownGetSize_16u_C1R(IppiSize srcRoi, Ipp32f rate, int kerSize, int* pStateSize, int* pBufSize);
IppStatus ippiPyramidLayerDownGetSize_16u_C3R(IppiSize srcRoi, Ipp32f rate, int kerSize, int* pStateSize, int* pBufSize);
IppStatus ippiPyramidLayerDownGetSize_32f_C1R(IppiSize srcRoi, Ipp32f rate, int kerSize, int* pStateSize, int* pBufSize);
IppStatus ippiPyramidLayerDownGetSize_32f_C3R(IppiSize srcRoi, Ipp32f rate, int kerSize, int* pStateSize, int* pBufSize);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

srcRoi  
Size of the source image ROI.
rate  
Ratio between neighbouring levels (1 < rate ≤ 10).
kerSize  
Size of the kernel.
pStateSize  
Pointer to the size of the pyramid layer state structure.
pBufSize  
Pointer to the size of the external work buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function computes the size of the pState structure to build a lower pyramid layer and the size of the temporary buffer, in bytes. This structure is used by the ippiPyramidLayerDown function and can be applied to process images with size not greater than srcRoi. For an example on how to use this function, refer to the example provided with the ippiPyramidLayerDown function description.

Return Values

ippStsNoErr  
Indicates no error.
ippStsNullPtrErr  
Indicates an error when at least one of the pointers is NULL.
Indicates an error when the width or height of images is less than, or equal to zero.
Indicates an error when $\text{kerSize}$ is even, or equal to or less than 0; or when $\text{rate}$ is out of the range.

See Also
Regions of Interest in Intel IPP
PyramidLayerDown  Creates a lower pyramid layer.

**PyramidLayerDownInit**
Initializes the structure for creating a lower pyramid layer.

**Syntax**

**Case 1: Operating on integer data**

IppStatus ippiPyramidLayerDownInit_8u_C1R(IppiPyramidDownState_8u_C1R** ppState, IppiSize srcRoi, Ipp32f rate, Ipp16s* pKernel, int kerSize, int mode, Ipp8u* pStateBuf, Ipp8u* pBuffer);
IppStatus ippiPyramidLayerDownInit_8u_C3R(IppiPyramidDownState_8u_C3R** ppState, IppiSize srcRoi, Ipp32f rate, Ipp16s* pKernel, int kerSize, int mode, Ipp8u* pStateBuf, Ipp8u* pBuffer);
IppStatus ippiPyramidLayerDownInit_16u_C1R(IppiPyramidDownState_16u_C1R** ppState, IppiSize srcRoi, Ipp32f rate, Ipp16s* pKernel, int kerSize, int mode, Ipp8u* pStateBuf, Ipp8u* pBuffer);
IppStatus ippiPyramidLayerDownInit_16u_C3R(IppiPyramidDownState_16u_C3R** ppState, IppiSize srcRoi, Ipp32f rate, Ipp16s* pKernel, int kerSize, int mode, Ipp8u* pStateBuf, Ipp8u* pBuffer);

**Case 2: Operating on floating point data**

IppStatus ippiPyramidLayerDownInit_32f_C1R(IppiPyramidDownState_32f_C1R** ppState, IppiSize srcRoi, Ipp32f rate, Ipp32f* pKernel, int kerSize, int mode, Ipp8u* pStateBuf, Ipp8u* pBuffer);
IppStatus ippiPyramidLayerDownInit_32f_C3R(IppiPyramidDownState_32f_C3R** ppState, IppiSize srcRoi, Ipp32f rate, Ipp32f* pKernel, int kerSize, int mode, Ipp8u* pStateBuf, Ipp8u* pBuffer);

**Include Files**
ippcv.h

**Domain Dependencies**
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

ppState  Pointer to the pointer to the initialized pyramid layer state structure.
srcRoi  Size of the source image ROI.
rate  Ratio between neighbouring levels ($1 < rate \leq 10$).
Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function initializes the pState structure to build a lower pyramid layer. This structure is used by the ippiPyramidLayerDown function and can be applied to process images with size not greater than dstRoi.

The specified kernel pKernel should be symmetric. If it is not symmetric, the function builds the symmetric kernel using the first part of the specified kernel and returns a warning. The symmetric separable kernel can be not Gaussian. If the sum of kernel elements is not equal to zero, the kernel is normalized.

For integer rates, the function performs downsampling by discarding rows and columns that are not multiples of the rate value. For non-integer rates, the function uses bilinear interpolation (see Linear Interpolation for more information).

For an example on how to use this function, refer to the example provided with the ippiPyramidLayerDown function description.

Return Values

ippStsNoErr Indicates no error.
ippStsNullPtrErr Indicates an error when at least one of the pointers is NULL.
ippStsSizeErr Indicates an error when the width or height of images is less than, or equal to zero.
ippStsBadArgErr Indicates an error when kerSize is even, or equal to or less than 0; or when rate is out of the range.

See Also

Regions of Interest in Intel IPP
PyramidLayerDown Creates a lower pyramid layer.
Linear Interpolation

PyramidLayerDown

Creates a lower pyramid layer.

Syntax

IppStatus ippiPyramidLayerDown_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppSize srcRoiSize, Ipp<datatype>* pDst, int dstStep, IppSize dstRoiSize, IppiPyramidDownState_<mod>* pState);

Supported values for mod:

8u_C1R 16u_C1R 32f_C1R
Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
pSrc
    Pointer to the source image ROI.
srcStep
    Distance, in bytes, between the starting points of consecutive lines in the source image.
srcRoiSize
    Size of the source image ROI, in pixels.
pDst
    Pointer to the destination image ROI.
dstStep
    Distance, in bytes, between the starting points of consecutive lines in the destination image.
dstRoiSize
    Size of the destination image ROI, in pixels.
pState
    Pointer to the pyramid layer structure.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function creates a lower pyramid layer pDst from the source image pSrc. The function applies the convolution kernel to the source image using the mirror border and then performs downsampling. Before callingippiPyramidLayerDown, compute the size of the pState structure and work buffer using the PyramidLayerDownGetSize function and initialize the structure using the PyramidLayerDownInit function. The function can process images with srcRoiSize not greater than the srcRoi parameter specified in the PyramidLayerDownInit function.

NOTE
This function uses the mirrored border.

Return Values
ippStsNoErr
    Indicates no error.
ippStsNullPtrErr
    Indicates an error if one of the specified pointers is NULL.
ippStsSizeErr
    Indicates an error condition if srcRoiSize or dstRoiSize has a field with zero or negative value.
ippStsStepErr
    Indicates an error condition if srcStep is less than srcRoiSize.width * <pixelSize>, or dstStep is less than dstRoiSize.width * <pixelSize>.
ippStsNotEvenStepErr
    Indicates an error condition if one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.
Indicates an error condition if \( p\text{State->rate} \) has wrong value.

**Example**

To better understand usage of the `ippiPyramidLayerDown` function, refer to the `PyramidLayerDown.c` example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

**See Also**

Regions of Interest in Intel IPP

PyramidLayerDownGetSize  Computes the size of the structure for creating a lower pyramid layer and the size of the temporary buffer.

PyramidLayerDownInit  Initializes the structure for creating a lower pyramid layer.

**PyramidLayerUpGetSize**

**Computes the size of the structure for creating an upper pyramid layer and the size of the temporary buffer.**

**Syntax**

```c
IppStatus ippiPyramidLayerUpGetSize_8u_C1R(IppiSize dstRoi, Ipp32f rate, int kerSize, int* pStateSize);
IppStatus ippiPyramidLayerUpGetSize_8u_C3R(IppiSize dstRoi, Ipp32f rate, int kerSize, int* pStateSize);
IppStatus ippiPyramidLayerUpGetSize_16u_C1R(IppiSize dstRoi, Ipp32f rate, int kerSize, int* pStateSize);
IppStatus ippiPyramidLayerUpGetSize_16u_C3R(IppiSize dstRoi, Ipp32f rate, int kerSize, int* pStateSize);
IppStatus ippiPyramidLayerUpGetSize_32f_C1R(IppiSize dstRoi, Ipp32f rate, int kerSize, int* pStateSize);
IppStatus ippiPyramidLayerUpGetSize_32f_C3R(IppiSize dstRoi, Ipp32f rate, int kerSize, int* pStateSize);
```

**Include Files**

`ippcv.h`

**Domain Dependencies**

Headers: `ippcore.h`, `ippvm.h`, `ipps.h`, `ippi.h`

Libraries: `ippcore.lib`, `ippvm.lib`, `ipps.lib`, `ippi.lib`

**Parameters**

- **dstRoi**
  - Size of the destination image ROI.
- **rate**
  - Ratio between neighbouring levels \( (1 < \text{rate} \leq 10) \).
- **kerSize**
  - Size of the kernel.
- **pStateSize**
  - Pointer to the size of the pyramid layer state structure.
This function operates with ROI (see Regions of Interest in Intel IPP).

This function computes the size of the pState structure to build an upper pyramid layer and the size of the temporary buffer, in bytes. This structure is used by the ippiPyramidLayerUp function and can be applied to process images with size not greater than dstRoi. For an example on how to use this function, refer to the example provided with the ippiPyramidLayerDown function description.

### Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error when at least one of the pointers is NULL.
- **ippStsSizeErr**: Indicates an error when the width or height of images is less than, or equal to zero.
- **ippStsBadArgErr**: Indicates an error when kerSize is even, or equal to or less than 0; or when rate is out of the range.

### See Also

- **Regions of Interest in Intel IPP**
- **PyramidLayerUp**: Creates an upper pyramid layer.
- **PyramidLayerDown**: Creates a lower pyramid layer.

### PyramidLayerUpInit

*Initializes the structure for creating an upper pyramid layer.*

### Syntax

**Case 1: Operating on integer data**

```c
IppStatus ippiPyramidLayerUpInit_8u_C1R(IppiPyramidUpState_8u_C1R** ppState, IppiSize dstRoi, Ipp32f rate, Ipp16s* pKernel, int kerSize, int mode, Ipp8u* pStateBuf);
IppStatus ippiPyramidLayerUpInit_8u_C3R(IppiPyramidUpState_8u_C3R** ppState, IppiSize dstRoi, Ipp32f rate, Ipp16s* pKernel, int kerSize, int mode, Ipp8u* pStateBuf);
IppStatus ippiPyramidLayerUpInit_16u_C1R(IppiPyramidUpState_16u_C1R** ppState, IppiSize dstRoi, Ipp32f rate, Ipp16s* pKernel, int kerSize, int mode, Ipp8u* pStateBuf);
IppStatus ippiPyramidLayerUpInit_16u_C3R(IppiPyramidUpState_16u_C3R** ppState, IppiSize dstRoi, Ipp32f rate, Ipp16s* pKernel, int kerSize, int mode, Ipp8u* pStateBuf);
```

**Case 2: Operating on floating point data**

```c
IppStatus ippiPyramidLayerUpInit_32f_C1R(IppiPyramidUpState_32f_C1R** ppState, IppiSize dstRoi, Ipp32f rate, Ipp32f* pKernel, int kerSize, int mode, Ipp8u* pStateBuf, Ipp8u* pBuffer);
IppStatus ippiPyramidLayerUpInit_32f_C3R(IppiPyramidDownState_32f_C3R** ppState, IppiSize dstRoi, Ipp32f rate, Ipp32f* pKernel, int kerSize, int mode, Ipp8u* pStateBuf, Ipp8u* pBuffer);
```

### Include Files

```c
ippcv.h
```
Domain Dependencies

**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

### Parameters

- **ppState**
  Pointer to the pointer to the initialized pyramid state structure.

- **dstRoi**
  Size of the destination image ROI.

- **rate**
  Ratio between neighbouring levels (1 < rate ≤ 10).

- **pKernel**
  Separable symmetric kernel of odd length.

- **kerSize**
  Size of the kernel.

- **mode**
  Interpolation method, possible value is:
  - IPPI_INTER_LINEAR  Bilinear interpolation.

- **pStateBuf**
  Pointer to the buffer to initialize the pyramid layer state structure.

### Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function allocates memory and initializes the `pState` structure to build an upper pyramid layer. This structure is used by the `ippiPyramidLayerUp` function and can be applied to process images with size not greater than `dstRoi`.

The specified kernel `pKernel` should be symmetric. If it is not symmetric, the function builds the symmetric kernel using the first part of the specified kernel and returns a warning. The symmetric separable kernel can be not Gaussian. If the sum of kernel elements is not equal to zero, the kernel is normalized.

For integer rates, the function performs upsampling by inserting zero rows and columns that are not multiples of the rate value. For non-integer rates, the function uses bilinear interpolation (see Linear Interpolation for more information) to calculate kernel coefficients for pixels with non-integer coordinates.

For an example on how to use this function, refer to the example provided with the `ippiPyramidLayerDown` function description.

### Return Values

- **ippStsNoErr**
  Indicates no error.

- **ippStsNullPtrErr**
  Indicates an error when at least one of the pointers is NULL.

- **ippStsSizeErr**
  Indicates an error when the width or height of images is less than, or equal to zero.

- **ippStsBadArgErr**
  Indicates an error when `kerSize` is even, or equal to or less than 0; or when `rate` is out of the range.

### See Also

- Regions of Interest in Intel IPP
- PyramidLayerUp  Creates an upper pyramid layer.
- PyramidLayerDown  Creates a lower pyramid layer.
- Linear Interpolation
**PyramidLayerUp**

*Creates an upper pyramid layer.*

**Syntax**

IppStatus ippiPyramidLayerUp_<mod>(const Ipp<datatype>* pSrc, int srcStep, IppiSize srcRoiSize, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, IppiPyramidUpState_<mod>* pState);

Supported values for <mod>:

- 8u_C1R
- 16u_C1R
- 32f_C1R
- 8u_C3R
- 16u_C3R
- 32f_C3R

**Include Files**

ippcv.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**
  - Pointer to the source image ROI.
- **srcStep**
  - Distance, in bytes, between the starting points of consecutive lines in the source image.
- **srcRoiSize**
  - Size of source image ROI, in pixels.
- **pDst**
  - Pointer to the destination image ROI.
- **dstStep**
  - Distance, in bytes, between the starting points of consecutive lines in the destination image.
- **dstRoiSize**
  - Size of destination image ROI, in pixels.
- **pState**
  - The pointer to the pyramid layer structure.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function creates an upper pyramid layer <pDst> from the source image <pSrc>. The function performs upsampling of the source image and then applies the convolution kernel using the mirror border. Before calling the ippiPyramidLayerUp function, compute the size of the pyramid layer structure <pState> using the PyramidLayerUpGetSize function and initialize the structure using the PyramidLayerUpInit function. The function can process images with <srcRoiSize> not greater than the <roiSize> parameter specified in the PyramidLayerUpInit function.

**NOTE**

This function uses the mirrored border.
Return Values

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error if one of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error condition if `srcRoiSize` or `dstRoiSize` has a field with zero or negative value.
- ippStsStepErr: Indicates an error condition if `srcStep` is less than `srcRoiSize.width * <pixelSize>`, or `dstStep` is less than `dstRoiSize.width * <pixelSize>`.
- ippStsNotEvenStepErr: Indicates an error condition if one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.
- ippStsBadArgErr: Indicates an error condition if `pState->rate` has wrong value.

See Also

- Regions of Interest in Intel IPP
- PyramidLayerDownGetSize: Computes the size of the structure for creating a lower pyramid layer and the size of the temporary buffer.
- PyramidLayerDownInit: Initializes the structure for creating a lower pyramid layer.

Example of Using General Pyramid Functions

Refer to the following example to understand how different general pyramids functions can be used to create the Gaussian and Laplacian pyramids:

Pyramid.c

Image Inpainting

The functions described in this section allows to restore the unknown image portions. They could be used to repair damaged parts of images and to remove some objects from images. Fast direct methods of inpainting that allow for run-time correcting of video frames are supported.

InpaintGetSize

Compresses the size of the state structure and work buffer for image inpainting.

Syntax

```c
IppStatus ippiInpaintGetSize(const Ipp8u* pMask, int maskStep, IppiSize roiSize, Ipp32f radius, IppiInpaintFlag flags, int channels, int* pStateSize, int* pBufSize);
```

Include Files

ippcv.h

Domain Dependencies

- Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
- Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Parameters

- **pMask**: Pointer to the mask image ROI.
- **maskStep**: Distance, in bytes, between the starting points of consecutive lines in the mask image.
- **roiSize**: Size of the image ROI, in pixels.
- **radius**: Radius of the neighborhood used for inpainting.
- **flags**: Specifies algorithm for image inpainting. Possible values:
  - IPP_INPAINT_TELEA: Telea algorithm
  - IPP_INPAINT_NS: Navier-Stokes equation
- **channels**: Number of channels in the image.
- **pStateSize**: Pointer to the size of the state structure.
- **pBufSize**: Pointer to the size of the external work buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function computes the size of the state structure for direct methods of image inpainting and the size of the external work buffer. Call this function before using **ippiInpaintInit**. For an example on how to use this function, refer to the example provided with the **ippiInpaint** function description.

Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error when width or height of the image is less than, or equal to zero.
- **ippStsStepErr**: Indicates an error when the step in the mask image is too small.
- **ippStsBadArgErr**: Indicates an error when **radius** is less than 1, or **flags** has an illegal value.
- **ippStsNumChannelsErr**: Indicates an error when the specified number of image channels is invalid or not supported.

See Also

- Regions of Interest in Intel IPP
- **Inpaint** MODIFIED API. Restores unknown image pixels.
- **InpaintInit** Initializes the state structure for image inpainting.

**InpaintInit**

*Initializes the state structure for image inpainting.*

Syntax

```c
IppStatus ippiInpaintInit_8u_C1R(IppiInpaintState_8u_C1R** ppState, const Ipp32f* pDist, int distStep, const Ipp8u* pMask, int maskStep, IppiSize roiSize, Ipp32f radius, IppiInpaintFlag flags, Ipp8u* pStateBuf, Ipp8u* pBuf);
```
IppStatusippiInpaintInit_8u_C3R(IppiInpaintState_8u_C3R** ppState, const Ipp32f*pDist, int distStep, const Ipp8u*pMask, int maskStep, IppiSize roiSize, Ipp32f radius, IppiInpaintFlag flags, Ipp8u*pStateBuf, Ipp8u*pBuf);

**Include Files**
ippcv.h

**Domain Dependencies**
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **ppState**
  Double pointer to the state structure for image inpainting.

- **pDist**
  Pointer to the ROI of the image of distances.

- **distStep**
  Distance, in bytes, between the starting points of consecutive lines in the image of distances.

- **pMask**
  Pointer to the mask image ROI.

- **maskStep**
  Distance, in bytes, between the starting points of consecutive lines in the mask image.

- **roiSize**
  Size of the image ROI, in pixels.

- **radius**
  Radius of the neighborhood used for inpainting (dist≤radius pixels are processed).

- **flags**
  Specifies algorithm for image inpainting. Possible values:
  - IPP_INPAINT_TELEA: Telea algorithm
  - IPP_INPAINT_NS: Navier-Stokes equation

- **pStateBuf**
  Pointer to the buffer for the state structure initialization.

- **pBuf**
  Pointer to the external work buffer.

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP).

This function initializes the ppState structure for direct methods of image inpainting. This structure is used by theippiInpaint function and can be applied to process images of the same size roiSize.

Zero pixels of the pMask image correspond to the known image pixels, non-zero pixels - to the unknown image pixels that should be restored. The distance image pDist specifies the order of pixel inpainting. Values of unknown pixels are restored in ascending order depending on their distances. The radius parameter specifies the radius of the circular neighborhood that affects the restoration of the central pixel. The flag parameter specifies the method of direct inpainting. Two methods are supported: Telea algorithm [Telea04] and Navier-Stokes equation [Bert01].

For an example on how to use this function, refer to the example provided with theippiInpaint function description.

**NOTE** The image ROI must not exceed the maximum width and height of roiSize specified in the initialization function.
Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error when one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error when width or height of the image is less than, or equal to zero.
- **ippStsStepErr**: Indicates an error when the step of the mask or distance image ROI is too small.
- **ippStsNotEvenStepErr**: Indicates an error when the step value is not divisible by the pDist element.
- **ippStsBadArgErr**: Indicates an error when radius is less than 1, or flags has an illegal value.

See Also

- Regions of Interest in Intel IPP
- Inpaint MODIFIED API. Restores unknown image pixels.
- InpaintGetSize Computes the size of the state structure and work buffer for image inpainting.

### Inpaint

**MODIFIED API. Restores unknown image pixels.**

#### Syntax

```c
IppStatus ippiInpaint_8u_C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, IppiInpaintState_8u_C1R* pState, Ipp8u* pBuffer);
IppStatus ippiInpaint_8u_C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pDst, int dstStep, IppiSize roiSize, IppiInpaintState_8u_C1R* pState, Ipp8u* pBuffer);
```

#### Include Files

ippcv.h

#### Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

#### Parameters

- **pSrc**: Pointer to the source image ROI.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the destination image ROI.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**: Size of the image ROI in pixels.
- **pState**: The pointer to the inpainting structure.
- **pBuffer**: Pointer to the work buffer.
Description

**Important** The API of this function has been modified in Intel IPP 9.0 release.

Before using this function, compute the size of the state structure and work buffer using `InpaintGetSize` and initialize the structure using `InpaintInit`.

This function operates with ROI (see Regions of Interest in Intel IPP).

This function reconstructs damaged part of the image, or removes a selected object (see Figure "Image Inpainting"). The image part to restore is defined by the mask that is created when the inpainting structure `pState` is initialized by the `InpaintInit` function. Different distant transforms can be used, but the Fast Marching method (`ippiFastMarching`) provides the best results. The order of pixel restoration is defined by the distance through the initialization the inpainting structure `pState` by the `InpaintInit` function. Pixels are restored in according to the growing of their distance value. When a pixel is inpainted, it is treated as the known one.

Two algorithms of direct inpainting are supported (controlled by the parameter `flags` of the `InpaintInit` function):

- image restoration of the unknown pixel by the weighted sum of approximations by known pixels in the neighborhood (`flags = IPP_INPAINT_TELEA`) [Telea04],
- image restoration based on the Navier-Stokes equations (`flags = IPP_INPAINT_NS`) [Bert01].

The inpainting structure `pState` can be used to perform restoration of several different images of the same size `roiSize`.

Image Inpainting

<table>
<thead>
<tr>
<th>Fast Digital</th>
<th>Inpainting</th>
</tr>
</thead>
<tbody>
<tr>
<td>initial image</td>
<td>restored image</td>
</tr>
</tbody>
</table>

Return Values

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error or a warning.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error when one of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error when <code>roiSize</code> has a field with zero or negative value, or if differs from the corresponding parameter that is specified when the inpainting structure is initialized by <code>InpaintInit</code>.</td>
</tr>
</tbody>
</table>
Indicates an error condition if srcStep or dstStep is less than roiSize.width * pixelSize.

Example

To better understand usage of the ippiInpaint function, refer to the Inpaint.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

See Also

InpaintGetSize Computes the size of the state structure and work buffer for image inpainting.
InpaintInit Initializes the state structure for image inpainting.

Image Segmentation

This section describes the functions that perform image segmentation using different techniques. These functions allow to extract parts of the image that can be associated with objects of the real world. Watershed and gradient segmentation are region-based methods to split image into the distinctive areas. Background/foreground segmentation allows for distinguishing between moving objects and stable areas of the background.

LabelMarkersGetBufferSize

Computes the size of the working buffer for the marker labeling.

Syntax

IppStatus ippiLabelMarkersGetBufferSize_8u_C1R(IppiSize roiSize, int* pBufSize);
IppStatus ippiLabelMarkersGetBufferSize_8u32s_C1R(IppiSize roiSize, int* pBufSize);
IppStatus ippiLabelMarkersGetBufferSize_16u_C1R(IppiSize roiSize, int* pBufSize);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

roiSize Size of the source image ROI in pixels.
pBufSize Pointer to the computed size of the working buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function computes the size of the working buffer required for the ippiLabelMarkers function. The buffer with the length pBufSize[0] can be used to segment images with width and/or height that is equal to or less than the corresponding field of the parameter roiSize.
Return Values

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error. Any other value indicates an error or a warning.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error condition if the pointer pBufSize is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error condition if roiSize has a field with zero or negative value.</td>
</tr>
</tbody>
</table>

LabelMarkers

Labels markers in image with different values.

Syntax

IppStatus ippiLabelMarkers_8u_C1IR(Ipp8u* pMarker, int markerStep, IppiSize roiSize, int minLabel, int maxLabel, IppiNorm norm, int* pNumber, Ipp8u* pBuffer);
IppStatus ippiLabelMarkers_8u32s_C1R(Ipp8u* pSrcMarker, int srcMarkerStep, Ipp32s* pDstMarker, int dstMarkerStep, IppiSize roiSize, int minLabel, int maxLabel, IppiNorm norm, int* pNumber, Ipp8u* pBuffer);
IppStatus ippiLabelMarkers_16u_C1IR(Ipp16u* pMarker, int markerStep, IppiSize roiSize, int minLabel, int maxLabel, IppiNorm norm, int* pNumber, Ipp8u* pBuffer);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>pMarker</td>
<td>Pointer to the source and destination image ROI (for in-place flavors).</td>
</tr>
<tr>
<td>markerStep</td>
<td>Distance in bytes between starts of consecutive lines in the source and destination image.</td>
</tr>
<tr>
<td>pSrcMarker</td>
<td>Pointer to the source image ROI (for not-in-place flavors).</td>
</tr>
<tr>
<td>srcMarkerStep</td>
<td>Distance, in bytes, between the starting points of consecutive lines in the source image (for not-in-place flavors).</td>
</tr>
<tr>
<td>pDstMarker</td>
<td>Pointer to the source and destination image ROI (for not-in-place flavors).</td>
</tr>
<tr>
<td>dstMarkerStep</td>
<td>Distance, in bytes, between the starting points of consecutive lines in the destination image (for not-in-place flavors).</td>
</tr>
<tr>
<td>minLabel</td>
<td>Minimal value of the marker label (0 &lt; minLabel ≤ maxLabel).</td>
</tr>
<tr>
<td>maxLabel</td>
<td>Maximal value of the marker label (minLabel ≤ maxLabel &lt; 255 for 8-bit markers, and minLabel ≤ maxLabel &lt; 65535 for 16-bit markers, and minLabel ≤ maxLabel &lt; (2^{31}.1) for 32-bit markers).</td>
</tr>
<tr>
<td>roiSize</td>
<td>Size of the source and destination image ROI in pixels.</td>
</tr>
</tbody>
</table>
**norm**
Specifies type of the norm to form the mask for marker propagation:

- ippiNormInf  
  Infinity norm (8-connectivity);
- ippiNormL1  
  L1 norm (4-connectivity).

**pNumber**
Pointer to the number of markers.

**pBuffer**
Pointer to the working buffer.

**Description**
This function operates with ROI (see Regions of Interest in Intel IPP).

This function labels markers in the destination image with different integer values. Each connected set of non-zero image pixels is treated as the separate marker. 4- or 8-connectivity can be used depending on the norm type. All pixels belonging to the same marker are set to the same value from the interval \([\text{minLabel}, \text{maxLabel}]\). Two markers can be labeled with the same value if the number of connected components exceeds \(\text{minLabel} - \text{maxLabel} + 1\). The image with labeled markers can be used as the seed image for segmentation by functions `ippiSegmentWatershed` or `ippiSegmentGradient` functions.

The function requires the working buffer `pBuffer` whose size should be computed by the function `ippiLabelMarkersGetBufferSize` beforehand.

**Return Values**

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error condition if one of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error condition if `roiSize` has a field with zero or negative value.
- ippStsStepErr: Indicates an error condition if `markerStep` is less than `roiSize.width * <pixelSize>`.
- ippStsNotEvenStepErr: Indicates an error condition if `markerStep`, `srcMarkerStep`, or `dstMarkerStep` is not divisible by respective `<pixelSize>`.
- ippStsBadArgErr: Indicates an error condition if one of the `minLabel`, `maxLabel`, and `norm` has an illegal value.

**Example**
To better understand usage of the `ippiLabelMarkers` function, refer to the `LabelMarkers.c` example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

**MarkSpecklesGetBufferSize**
*Computes the size of the external work buffer for speckle marking.*

**Syntax**

```
IppStatusippiMarkSpecklesGetBufferSize(IppiSize roiSize, IppDataType dataType, int numChannels, int* pBufferSize);
```
Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters
roiSize  Size of the source and destination image ROI in pixels.
dataType  Data type of the source and destination image.
numChannels  Number of channels in the image. Possible value is 1.
pBufferSize  Pointer to the computed size (in bytes) of the external work buffer.

Description
This function computes the size of the external work buffer for the MarkSpeckles function.
For an example on how to use this function, refer to the example provided with the MarkSpeckles function description.

Return Values
ippStsNoErr  Indicates no error. Any other value indicates an error.
ippStsNullPtrErr  Indicates an error when pBufferSize is NULL.
ippStsSizeErr  Indicates an error when roiSize has a field with a zero or negative value.
ippStsDataTypeErr  Indicates an error when dataType has an illegal value.
ippStsNumChannelErr  Indicates an error when numChannels has an illegal value.

See Also
MarkSpeckles  Marks small noise blobs (speckles) in an image.

MarkSpeckles
Marks small noise blobs (speckles) in an image.

Syntax
IppStatus ippiMarkSpeckles_<mod>(Ipp<datatype>* pSrcDst, int srcDstStep, IppiSize roiSize, Ipp<datatype> speckleVal, int maxSpeckleSize, Ipp<datatype> maxPixDiff, IppiNorm norm, Ipp8u* pBuffer);

Supported values for mod:
8u_C1IR  16u_C1IR  16s_C1IR  32f_C1IR

Include Files
ippcv.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrcDst  
Pointer to the source and destination image.

srcDstStep  
Distance, in bytes, between the starting points of consecutive lines in the source and destination image.

roiSize  
Size of the source and destination image ROI in pixels.

speckleVal  
Value to set to the speckles.

maxSpeckleSize  
Maximum size of the image component to consider it as a speckle.

maxPixDiff  
Maximum difference between neighboring disparity pixels to put them into the same component.

norm  
Type of the norm to form the mask for marker propagation. Possible value is:

ippiNormL1  
L1 norm (4-connectivity)

pBuffer  
Pointer to the work buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function marks small noise blobs (speckles) in the source image.

The pSrcDst parameter points to the processed source and destination image ROI.

The function finds small connected components and set them to the speckleVal value. This function marks only components with size that is less than, or equal to maxSpeckleSize. Pixels of the image belong to the same connected component if the difference between adjacent pixels (considering 4-connected adjacency) is less than, or equal to the maxSpeckleSize value.

NOTE
This release does not support 8-connectivity.

The function does not process the pixels of the image that already have the speckleVal value.

Before using the ippiMarkSpeckles function, compute the size of the external buffer using the MarkSpecklesGetBufferSize function.

Return Values

ippStsNoErr  
Indicates no error.

ippiStsNullPtrErr  
Indicates an error when pSrcDst or pBufferSize is NULL.

ippiStsSizeErr  
Indicates an error when roiSize has a field with a zero or negative value.
ippStsNotEvenStepErr
Indicates an error when one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.

ippStsNormErr
Indicates an error when norm has an incorrect or not supported value.

Example
To better understand usage of the ippiMarkSpeckles function, refer to the MarkSpeckles.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

See Also
Regions of Interest in Intel IPP
User-defined Border Types
FilterGaussianGetBufferSize Computes the size of the Gaussian specification structure and the size of the external work buffer for Gaussian filtering with user-defined borders.
FilterGaussianInit Initializes the Gaussian context structure.

SegmentWatershedGetBufferSize
Computes the size of the working buffer for the watershed segmentation.

Syntax
IppStatus ippiSegmentWatershedGetBufferSize_8u_C1R(IppiSize roiSize, int* pBufSize);
IppStatus ippiSegmentWatershedGetBufferSize_8u16u_C1R(IppiSize roiSize, int* pBufSize);
IppStatus ippiSegmentWatershedGetBufferSize_32f16u_C1R(IppiSize roiSize, int* pBufSize);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
roiSize
Size of the source image ROI in pixels.
pBufSize
Pointer to the computed size of the working buffer.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function computes the size of the working buffer required for the ippiSegmentWatershed function. The buffer with the length pBufSize[0] can be used to segment images with width and/or height that is equal to or less than the corresponding field of the parameter roiSize.

Return Values
ippStsNoErr
Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr
Indicates an error condition if the pointer pBufSize is NULL.

ippStsSizeErr
Indicates an error condition if roiSize has a field with zero or negative value.

SegmentWatershed
Performs marker-controlled watershed segmentation of an image.

Syntax
IppStatus ippiSegmentWatershed_8u_C1IR(const Ipp8u* pSrc, int srcStep, Ipp8u* pMarker, int markerStep, IppiSize roiSize, IppiNorm norm, int flag, Ipp8u* pBuffer);
IppStatus ippiSegmentWatershed_8u16u_C1IR(const Ipp8u* pSrc, int srcStep, Ipp16u* pMarker, int markerStep, IppiSize roiSize, IppiNorm norm, int flag, Ipp8u* pBuffer);
IppStatus ippiSegmentWatershed_32f16u_C1IR(const Ipp32f* pSrc, int srcStep, Ipp16u* pMarker, int markerStep, IppiSize roiSize, IppiNorm norm, int flag, Ipp8u* pBuffer);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc
Pointer to the source image ROI.

crcStep
Distance, in bytes, between the starting points of consecutive lines in the source image.

pMarker
Pointer to the ROI of the source and destination image of markers.

markerStep
Distance, in bytes, between the starting points of consecutive lines in the image with markers.

roiSize
Size of the source and destination image ROI, in pixels.

norm
Specifies the type of the norm to form the mask for marker propagation:

ippiNormInf
Infinity norm (8-connectivity, 3x3 rectangular mask)

ippiNormL1
L1 norm (4-connectivity, 3x3 cross mask)

ippiNormL2
Approximation of L2 norm (8-connectivity, 3x3 mask) [Bor86]

ippiNormFM
Fast marching distance [Telea04]

flag
Specifies the algorithm of segmentation. The value is a logical sum of the following mandatory values:

IPP_SEGMENT_QUEUE
Priority queue is used to define the order of pixel processing.
IPP_SEGMENT_DISTANCE  Distance transform algorithm is used for segmentation.

and the following optional values:

IPP_SEGMENT_BORDER_4  Pixels of the 4-connectivity border between image segments are marked with the IPP_MAX_8U (255) value.

IPP_SEGMENT_BORDER_8  Pixels of the 8-connectivity border between image segments are marked with the IPP_MAX_8U (255) value.

pBuffer  Pointer to the working buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function performs marker-controlled watershed segmentation of the source image. Non-zero pixels of the pMarker image belong to water source markers. Marker values propagate through the whole image according to the watershed algorithm. Image segments are formed by groups of connected pMarker pixels with the same value. The parameter norm controls marker propagation connectivity. Watershed segmentation is preferable for images with local minimums, for example, gradient images. Image markers generally correspond to these local minimums and can be created, for example, manually or using morphological reconstruction.

The parameter flag specifies how watershed segmentation is performed. This parameter is a logical sum of two values among the following supported values:

- Mandatory values specifying the algorithm of segmentation:
  
  IPP_SEGMENT_QUEUE  Classic watershed segmentation scheme with the priority queue [Vincent91]

  IPP_SEGMENT_DISTANCE  Watershed segmentation by calculating the topographic distance for each pixel [Lotufo00], [Meyer94]

- Optional additional values of the flag: IPP_SEGMENT_BORDER_4 and IPP_SEGMENT_BORDER_8 specify the border of the segments. All pixels adjacent to the differently marked pixels are considered as border pixels, and their values are set to IPP_MAX_8U (255) for 8-bit markers, or IPP_MAX_16U (65535) for 16-bit markers. In this case, the value IPP_MAX_8U (IPP_MAX_16U) should not be used to mark segments. If these optional values are not specified, segments are formed without borders.

The function requires the working buffer pBuffer, which size should be computed by the functionippiSegmentWatershedGetBufferSize beforehand.

Figure “Watershed Segmentation with Different Norms” shows the plateau filling through the watershed segmentation with different values of the norm parameters. Initial image (a) has the labeled with markers upper and lower fourths with low pixel value, the central plateau between them, the ridge between the
plateau and the lower forth with one pixel hole in the center of it. The following pictures are segmentation results: b) - for L1 norm (block distance), c)- Linf norm (chessboard distance), d) - approximate L2 (Euclidian) norm [Bor86], e) Fast Marching distance.

### Watershed Segmentation with Different Norms

<table>
<thead>
<tr>
<th>Plateau</th>
<th>Ridge</th>
<th>Watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hole</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a)</td>
<td>b)</td>
<td>c)</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d)</td>
<td>e)</td>
<td></td>
</tr>
</tbody>
</table>

### Return Values

- **ippStsNoErr**: Indicates no error. Any other value indicates an error or a warning.
- **ippStsNullPtrErr**: Indicates an error condition if one of the specified pointers is NULL.
- **ippStsSizeErr**: Indicates an error condition if roiSize has a field with zero or negative value.
- **ippStsStepErr**: Indicates an error condition if one of the srcStep or markerStep is less than roiSize.width * pixelSize.
- **ippNotEvenStsStepErr**: Indicates an error condition if one of the srcStep or markerStep for 16-bit integer images is not divisible by 2.
- **ippStsBadArgErr**: Indicates an error condition if norm has an illegal value.
SegmentGradientGetBufferSize

Computes the size of the working buffer for the gradient segmentation.

Syntax

IppStatus ippiSegmentGradientGetBufferSize_8u_C1R(IppiSize roiSize, int* pBufferSize);
IppStatus ippiSegmentGradientGetBufferSize_8u_C3R(IppiSize roiSize, int* pBufSize);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

roiSize          Size of the source image ROI in pixels.
pBufSize, pBufferSize   Pointer to the computed size of the working buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).
This function computes the size of the working buffer required for the ippiSegmentGradient function. The buffer with the length pBufSize[0] can be used to segment images with width and/or height that is equal to or less than the corresponding field of the parameter roiSize.

Return Values

ippStsNoErr      Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error condition if the pointer pBufSize is NULL.
ippStsSizeErr    Indicates an error condition if roiSize has a field with zero or negative value.

SegmentGradient

Performs image segmentation by region growing to the least gradient direction.

Syntax

IppStatus ippiSegmentGradient_8u_C1R(const Ipp8u* pSrc, int srcStep, Ipp8u* pMarker, int markerStep, IppiSize roiSize, IppiNorm norm, int flags, Ipp8u* pBuffer);
IppStatus ippiSegmentGradient_8u_C3R(const Ipp8u* pSrc, int srcStep, Ipp8u* pMarker, int markerStep, IppiSize roiSize, IppiNorm norm, int flags, Ipp8u* pBuffer);

Include Files

ippcv.h
**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pSrc**
  Pointer to the source image ROI.

- **srcStep**
  Distance in bytes between starts of consecutive lines in the source image.

- **pMarker**
  Pointer to the ROI of the source and destination image of markers.

- **markerStep**
  Distance in bytes between starts of consecutive lines in the image of markers.

- **roiSize**
  Size of the source and destination image ROI in pixels.

- **norm**
  Specifies type of the norm to form the mask for marker propagation:
  - **ippiNormInf**
    Infinity norm (8-connectivity, 3x3 rectangular mask);
  - **ippiNormL1**
    L1 norm (4-connectivity, 3x3 cross mask);

- **flags**
  optional flag:
  - **IPP_SEGMENT_BORDER_4**
    pixels of the 4-connectivity border between image segments are marked with value (IPP_MAX_8U)-1 (254).
  - **IPP_SEGMENT_BORDER_8**
    pixels of the 8-connectivity border between image segments are marked with value (IPP_MAX_8U)-1 (254).

- **pBuffer**
  Pointer to the working buffer.

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function performs image segmentation by region growing with markers. Non-zero pixels of **pMarker** image belong to initial image regions. Marker values propagate through the whole image in the direction of the least value of the absolute value of the image gradient. For 3-channel image the gradient is calculated as the maximum of channel gradients. Image segments are formed by groups of connected **pMarker** pixels with the same value. The parameter **norm** controls marker propagation connectivity. Gradient segmentation is generally done for an image without explicit calculation of the image gradient. [Meyer92]

If **IPP_SEGMENT_BORDER** flag is defined, then the pixels adjacent to differently marked pixels are assumed to be border pixels and are set to a special value (254). This value must not be used to mark segments in this case.

Another special value (255) is used inside the function and can not be used to mark segment in any case.

The function requires the working buffer **pBuffer** whose size should be computed by the function **ippiSegmentGradientGetBufferSize** beforehand.

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.
Indicates an error condition if one of the specified pointers is NULL.

Indicates an error condition if roiSize has a field with zero or negative value.

Indicates an error condition if one of the srcStep or markerStep is less than roiSize.width * pixelSize.

Indicates an error condition if norm has an illegal value.

**BoundSegments**

Marks pixels belonging to segment boundaries.

**Syntax**

IppStatus ippiBoundSegments_8u_C1IR(Ipp8u* pMarker, int markerStep, IppiSize roiSize, Ipp8u val, IppiNorm norm);

IppStatus ippiBoundSegments_16u_C1IR(Ipp16u* pMarker, int markerStep, IppiSize roiSize, Ipp16u val, IppiNorm norm);

**Include Files**

ippcv.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pMarker**
  Pointer to the ROI of the source and destination image of markers.
- **markerStep**
  Distance in bytes between starts of consecutive lines in the image of markers.
- **roiSize**
  Size of the source and destination image ROI in pixels.
- **val**
  Value of the boundary pixel.
- **norm**
  Specifies type of the norm for pixel neighborhood:
  - ippiNormInf: Infinity norm (8-connectivity);
  - ippiNormL1: L1 norm (4-connectivity).

**Description**

This function operates with ROI (see Regions of Interest in Intel IPP).

This function detects segment boundaries in the **pMarker** image and sets border pixels to the value **val**. A segment is the set of connected pixels of the **pMarker** image with the same value not equal to **val**. After boundaries are marked, the **pMarker** image does not contain any pair of adjacent in **norm** pixels with the same value that not equal to **val**.

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error or a warning.
**Pattern Recognition**

**Object Detection Using Haar-like Features**

The object detector described in [Viola01] and [Lein02] is based on Haar classifiers. Each classifier uses $k$ rectangular areas (Haar features) to make decision if the region of the image looks like the predefined image or not. Figure “Types of Haar Features” shows different types of Haar features.
In the Intel IPP Haar features are represented using `IppRect` structure. Figure “Representing Haar Features” shows how it can be done for common and tilted features.

**Representing Haar Features**

When the classifier \( K \) is applied to the pixel \((i, j)\) of the image \( A \), it yields the value \( \text{val1}(t) \) if

\[
\sum_{i = 1}^{R_1} \left( \sum_{u = i}^{R_1-y} \sum_{v = j}^{R_1-x} A_{uv} \right) < \text{norm}(i, j) \cdot \text{threshold}(t)
\]

and \( \text{val2}(t) \) otherwise.

Here \( w_1 \) is a feature weight, \( \text{norm}(i, j) \) is the norm factor (generally the standard deviation on the rectangle containing all features), \( \text{threshold}(t) \), \( \text{val1}(t) \) and \( \text{val2}(t) \) are parameters of the classifier. For fast computation the integral representation of an image is used. Haar classifiers are organized in sequences called stages (classification stages). The stage value is the sum of its classifier values. During feature detecting stages are consequently applied to the region of the image until the stage value becomes less than the threshold value or all stages are passed.

**HaarClassifierGetSize**

Computes the size of the structure for standard Haar classifiers.

**Syntax**

\[
\text{IppStatus ippiHaarClassifierGetSize(IppDataType dataType, IppiSize roiSize, const int* pNum, int length, int* pSize)};
\]

**Include Files**

ippcv.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- `dataType` Data type of the source image. Possible values: `ipp32f`, `ipp32s`.
- `roiSize` Maximal size of the source image ROI, in pixels.
pNum  
Pointer to the array of Haar classifier lengths.

length  
Number of classifiers in the stage.

pSize  
Pointer to the size of Haar classifier structure.

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function computes the size of the pState structure that is required to calculate the sequence of Haar classifiers - classification stage. The i-th classifier in the stage has pNum[i] rectangular features.
The length of the pThreshold, pVal1, and pVal2 vectors used in theippiHaarClassifierInit function is equal to length.
The length of the pFeature and pWeight vectors is equal to:

\[
\sum_{i=0}^{\text{length}-1} \text{pNum}[i]
\]

Return Values
ippStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  
Indicates an error when any of the specified pointers is NULL.

ippStsSizeErr  
Indicates an error when:

- length or one of the pNum[i] values is less than, or equal to zero
- roiSize has a field with a zero or negative value

ippStsBadArgErr  
Indicates an error when one of the features is defined incorrectly.

ippStsDataTypeErr  
Indicates an error when dataType has an illegal value.

See Also
Regions of Interest in Intel IPP
HaarClassifierInit  Initializes the structure for standard Haar classifiers.
ApplyHaarClassifier  Applies a Haar classifier to an image.

HaarClassifierInit
Initializes the structure for standard Haar classifiers.

Syntax
IppStatus ippiHaarClassifierInit_32f(IppiHaarClassifier_32f** ppState, const IppiRect* pFeature, const Ipp32f* pWeight, const Ipp32f* pThreshold, const Ipp32f* pVal1, const Ipp32f* pVal2, const int* pNum, int length);
IppStatus ippiHaarClassifierInit_32s(IppiHaarClassifier_32s** ppState, const IppiRect* pFeature, const Ipp32s* pWeight, const Ipp32s* pThreshold, const Ipp32s* pVal1, const Ipp32s* pVal2, const int* pNum, int length);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters
ppState Double pointer to the Haar classifier structure.
pFeature Pointer to the array of features.
pWeight Pointer to the array of feature weights.
pThreshold Pointer to the array of classifier threshold values.
pVal1, pVal2 Pointers to the arrays of classifier result values.
pNum Pointer to the array of Haar classifier lengths.
length Number of classifiers in the stage.

Description
This function initializes the state structure that is required to calculate the sequence of Haar classifiers - classification stage. The i-th classifier in the stage has pNum[i] rectangular features. Each feature is defined by a certain rectangle with horizontal and vertical sides. The length of the pThreshold, pVal1, and pVal2 vectors is equal to length. The length of pFeature and pWeight is equal to:

\[
\sum_{i=0}^{\text{length}-1} pNum[i]
\]

Result of applying classifiers to the image is computed using the formula in "Object Detection Using Haar-like Features".

All features of the classifier initialized by the ippiHaarClassifierInit function have vertical and horizontal sides (left part of Figure “Representing Haar Features”). Some of these features then can be tilted using the ippiTiltHaarFeatures function.

Return Values
ippStsNoErr Indicates no error. Any other value indicates an error or a warning.
ippStsNullPtrErr Indicates an error when any of the specified pointers is NULL.
**ippStsSizeErr**
Indicates an error when `length` or one of the `pNum[i]` values is less than, or equal to zero.

**ippStsBadArgErr**
Indicates an error when one of the features is defined incorrectly.

**See Also**

- **HaarClassifierGetSize** Computes the size of the structure for standard Haar classifiers.
- **ApplyHaarClassifier** Applies a Haar classifier to an image.
- **Object Detection Using Haar-like Features**
- **TiltHaarFeatures** Modifies a Haar classifier by tilting specified features.

---

**GetHaarClassifierSize**

*Returns the size of the Haar classifier.*

**Syntax**

```c
IppStatus ippiGetHaarClassifierSize_32f(IppiHaarClassifier_32f* pState, IppiSize* pSize);
IppStatus ippiGetHaarClassifierSize_32s(IppiHaarClassifier_32s* pState, IppiSize* pSize);
```

**Include Files**

ippcv.h

**Domain Dependencies**

*Headers:* ippcore.h, ippvm.h, ipps.h,ippi.h
*Libraries:* ippcore.lib, ippvm.lib,ipps.lib,ippi.lib

**Parameters**

- **pState**  
  Pointer to the Haar classifier structure.
- **pSize**  
  Pointer to the size of Haar classifier structure.

**Description**

This function computes the minimum size of the window containing all features of the Haar classifier described by the `pState`.

**Return Values**

- **ippStsNoErr**  
  Indicates no error.
- **ippStsNullPtrErr**  
  Indicates an error condition if the `pState` pointer is NULL.

---

**TiltedHaarClassifierInit**

*Initializes the structure for tilted Haar classifiers.*

**Syntax**

```c
IppStatus ippiTiltedHaarClassifierInit_32f(IppiHaarClassifier_32f* pState, const IppiRect* pFeature, const Ipp32f* pWeight, const Ipp32f* pThreshold, const Ipp32f* pVal1, const Ipp32f* pVal2, const int* pNum, int length);
```
IppStatusippiTilTiltedHaarClassifierInit_32s(IppiHaarClassifier_32s* pState, const IppRect* pFeature, const Ipp32s* pWeight, const Ipp32s* pThreshold, const Ipp32s* pVal1, const Ipp32s* pVal2, const int* pNum, int length);

**Include Files**

ippcv.h

**Domain Dependencies**

**Headers:** ippcore.h, ippvm.h, ipps.h,ippi.h

**Libraries:** ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- **pState**
  
  Double pointer to the Haar classifier structure.

- **pFeature**
  
  Pointer to the array of features.

- **pWeight**
  
  Pointer to the array of feature weights.

- **pThreshold**
  
  Pointer to the array of classifier threshold values.

- **pVal1, pVal2**
  
  Pointers to the arrays of classifier result values.

- **pNum**
  
  Pointer to the array of Haar classifier lengths.

- **length**
  
  Number of classifiers in the stage.

**Description**

This function initializes the state structure that is required to calculate the sequence of Haar classifiers - classification stage. The i-th classifier in the stage has \( \text{pNum}[i] \) rectangular features. Each feature is defined by a certain rectangle with sides tilted by 45 degrees. You should specify the points with minimum and maximum row numbers. The length of the \( \text{pFeature}, \text{pFeature}, \text{pWeight}, \text{pVal1}, \text{and} \ \text{pVal2} \) vectors is equal to:

\[
\sum_{i=0}^{\text{length}-1} \text{pNum}[i]
\]

Result of applying classifiers to the image is computed using the formula in "Object Detection Using Haar-like Features".

All features of the classifier initialized by the \text{ippiTilTiltedHaarClassifierInit} function have tilted sides (right part of Figure "Representing Haar Features").

**Return Values**

- **ippStsNoErr**
  
  Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**
  
  Indicates an error when any of the specified pointers is NULL.

- **ippStsSizeErr**
  
  Indicates an error when:
• length or one of the pNum[i] values is less than, or equal to zero
• Sum of all elements of pNum is not equal to length

ippStsBadArgErr Indicates an error when one of the features is defined incorrectly.

See Also
ApplyHaarClassifier Applies a Haar classifier to an image.
Object Detection Using Haar-like Features
TiltHaarFeatures Modifies a Haar classifier by tilting specified features.

TiltHaarFeatures
Modifies a Haar classifier by tilting specified features.

Syntax
IppStatusippiTiltHaarFeatures_32f(constIpp8upMask, intflag,
IpplHaarClassifier_32f*pState);
IppStatusippiTiltHaarFeatures_32s(constIpp8upMask, intflag,
IpplHaarClassifier_32s*pState);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters
pMask Pointer to the mask vector.
flag Flag to choose the direction of feature tilting.
pState Pointer to the Haar classifier structure.

Description
This function tilts specified features of the Haar classifier. Before using this function, compute the size of the Haar classifier state structure using HaarClassifierGetSize and initialize the structure using TiltedHaarClassifierInit. Non-zero elements of previously prepared vector pMask indicates the features that are tilted. The flag parameter specifies how the features are tilted:
• if flag is equal to 0, the feature is tilted around the left top corner clockwise
• if flag is equal to 1, the feature is tilted around the bottom left corner counter-clockwise

This mixed classifier containing both common and tilted features can be used by the functionippiApplyMixedHaarClassifier.

Return Values
ippStsNoErr Indicates no error.
ippStsNullPtrErr Indicates an error when one of the specified pointers is NULL.
ippStsBadArgErr Indicates an error when the classifier is tilted already.
See Also
HaarClassifierGetSize  Computes the size of the structure for standard Haar classifiers.
TiltedHaarClassifierInit  Initializes the structure for tilted Haar classifiers.

ApplyHaarClassifier
Applies a Haar classifier to an image.

Syntax
IppStatus ippiApplyHaarClassifier_32f_C1R(const Ipp32f* pSrc, int srcStep, const Ipp32f* pNorm, int normStep, Ipp8u* pMask, int maskStep, IppiSize roiSize, int* pPositive, Ipp32f threshold, IppiHaarClassifier_32f* pState);
IppStatus ippiApplyHaarClassifier_32s32f_C1R(const Ipp32s* pSrc, int srcStep, const Ipp32f* pNorm, int normStep, Ipp8u* pMask, int maskStep, IppiSize roiSize, int* pPositive, Ipp32f threshold, IppiHaarClassifier_32f* pState);
IppStatus ippiApplyHaarClassifier_32s_C1RSfs(const Ipp32s* pSrc, int srcStep, const Ipp32s* pNorm, int normStep, Ipp8u* pMask, int maskStep, IppiSize roiSize, int* pPositive, Ipp32s threshold, IppiHaarClassifier_32s* pState, int scaleFactor);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h, ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib, ippi.lib

Parameters
pSrc  Pointer to the ROI in the source image of integrals.
srcStep  Distance, in bytes, between the starting points of consecutive lines in the source image.
pNorm  Pointer to the ROI in the source image of norm factors.
normStep  Distance, in bytes, between the starting points of consecutive lines in the image of the norm factors.
pMask  Pointer to the source and destination image of classification decisions.
maskStep  Distance, in bytes, between the starting points of consecutive lines in the image of classification decisions.
pPositive  Pointer to the number of positive decisions.
roiSize  Size of the source and destination images ROI in pixels.
threshold  Stage threshold value.
pState  Pointer to the Haar classifier structure.
scaleFactor  Scale factor (see Integer Result Scaling).

Description
This function operates with ROI (see Regions of Interest in Intel IPP).
This function applies the Haar classifier to pixels of the source image ROI \( p_{Src} \). The source image should be in the integral representation, it can be obtained by calling one of the integral functions beforehand. The sum of pixels on feature rectangles is computed as:

\[
\sum_{j=1}^{k} [p_{Src}[i+y_1,j+x_1] - p_{Src}[i+y_1,j+x_2] - p_{Src}[i+y_2,j+x_1] + p_{Src}[i+y_2,j+x_2]] \cdot w_l
\]

Here \((y_l, x_l)\) and \((Y_l, X_l)\) are coordinates of top left and right bottom pixels of \( l \)-th rectangle of the feature, and \( w_l \) is the feature weight. For \( i = 0 \). roiSize.height - 1, \( j = 0 \). roiSize.width - 1 all pixels referred in the above formula should be allocated in memory.

The input value of \( p_{Positive}[0] \) is used as a hint to choose the calculation algorithm. If it is greater than or equal to \( \text{roiSize.width} \times \text{roiSize.height} \), the value of the classifier is calculated in accordance with the above formula for all pixels of the input image. Otherwise the value of the classifier is calculated for all non-zero pixels of \( p_{Mask} \) image. If the sum is less than \( \text{threshold} \) than the negative decision is made and the value of the corresponding pixel of the \( p_{Mask} \) image is set to zero. The number of positive decisions is assigned to the \( p_{Positive}[0] \).

Before using this function, you need to compute the size of the state structure using \texttt{HaarClassifierGetSize} and initialize the structure using \texttt{HaarClassifierInit} or \texttt{TiltedHaarClassifierInit}.

**Return Values**

- \texttt{ippStsNoErr} Indicates no error.
- \texttt{ippStsNullPtrErr} Indicates an error when one of the specified pointers is \texttt{NULL}.
- \texttt{ippStsSizeErr} Indicates an error when \( \text{roiSize} \) has a field with a zero or negative value.
- \texttt{ippStsStepErr} Indicates an error when one of the image step values is less than \( \text{roiSize.width} \times \text{pixelSize} \).
- \texttt{ippStsNorEvenStepErr} Indicates an error when one of the image step values is not divisible by 4 for 32-bit images.

**See Also**

- \texttt{HaarClassifierGetSize} Computes the size of the structure for standard Haar classifiers.
- \texttt{HaarClassifierInit} Initializes the structure for standard Haar classifiers.
- \texttt{TiltedHaarClassifierInit} Initializes the structure for tilted Haar classifiers.

**ApplyMixedHaarClassifier**

Applies a mixed Haar classifier to an image.

**Syntax**

```c
IppStatus ippiApplyMixedHaarClassifier_32f_C1R(const Ipp32f* pSrc, int srcStep, const Ipp32f* pTilt, int tiltStep, const Ipp32f* pNorm, int normStep, Ipp8u* pMask, int maskStep, IppSize roiSize, int* pPositive, Ipp32f threshold, IppiHaarClassifier_32f* pState);
```

```c
IppStatus ippiApplyMixedHaarClassifier_32s32f_C1R(const Ipp32s* pSrc, int srcStep, const Ipp32s* pTilt, int tiltStep, const Ipp32f* pNorm, int normStep, Ipp8u* pMask, int maskStep, IppSize roiSize, int* pPositive, Ipp32f threshold, IppiHaarClassifier_32f* pState);
```
IppStatus ippiApplyMixedHaarClassifier_32s_C1RSfs(const Ipp32s* pSrc, int srcStep, const Ipp32s* pTilt, int tiltStep, const Ipp32s* pNorm, int normStep, Ipp8u* pMask, int maskStep, IippiSize roiSize, int* pPositive, Ipp32s threshold, IppiHaarClassifier_32s* pState, int scaleFactor);

Include Files
ippcv.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pSrc
Pointer to the ROI in the source image of integrals.

srcStep
Distance, in bytes, between the starting points of consecutive lines in the source image of integrals.

pTilt
Pointer to the ROI in the source image of tilted integrals.

tiltStep
Distance, in bytes, between the starting points of consecutive lines in the source image of tilted integrals.

pNorm
Pointer to the ROI in the source image of norm factors.

normStep
Distance, in bytes, between the starting points of consecutive lines in the image of the norm factors.

pMask
Pointer to the source and destination image of classification decisions.

maskStep
Distance, in bytes, between the starting points of consecutive lines in the image of classification decisions.

pPositive
Pointer to the number of positive decisions.

roiSize
Size of the source and destination images ROI in pixels.

threshold
Stage threshold value.

pState
Pointer to the mixed Haar classifier structure.

scaleFactor
Scale factor (see Integer Integer Result Scaling).

Description
This function operates with ROI (see Regions of Interest in Intel IPP).

This function applies the mixed Haar classifier pState to the ROI of the source images pSrc and pTilt. The mixed Haar classifier is a classifier initialized by HaarClassifierInit and then modified by the TiltHaarFeatures function. The source images must be in the integral representation, they can be obtained by calling one of the integral functions beforehand. Common features are applied to the pSrc image, and tilted features are applied to the pTilt image. The sum of pixels on feature rectangles is computed as:
Here \((y_l, x_l)\) and \((y_u, x_u)\) are coordinates of top left and right bottom pixels of \(l\)-th rectangle of the feature, and \(w_l\) is the feature weight. For \(i = 0.\ roiSize.height - 1, j = 0.\ roiSize.width - 1\) all pixels referred in the above formula should be allocated in memory.

The input value of \(pPositive[0]\) is used as a hint to choose the calculation algorithm. If it is greater than or equal to \(roiSize.width*roiSize.height\) the value of the classifier is calculated in accordance with the above formula for all pixels of the input image. Otherwise the value of the classifier is calculated for all non-zero pixels of \(pMask\) image. If the sum is less than \(threshold\) than the negative decision is made and the value of the corresponding pixel of the \(pMask\) image is set to zero. The number of positive decisions is assigned to the \(pPositive[0]\).

**Return Values**

- **ippStsNoErr**
  Indicates no error.

- **ippStsNullPtrErr**
  Indicates an error when one of the specified pointers is NULL.

- **ippStsSizeErr**
  Indicates an error when \(roiSize\) has a field with a zero or negative value.

- **ippStsStepErr**
  Indicates an error when one of the image step values is less than \(roiSize.width*<pixelSize>\).

- **ippStsNorEvenStepErr**
  Indicates an error when one of the image step values is not divisible by 4 for 32-bit images.

**See Also**

- **Regions of Interest in Intel IPP**
- **HaarClassifierInit** Initializes the structure for standard Haar classifiers.
- **TiltHaarFeatures** Modifies a Haar classifier by tilting specified features.

### Local Binary Pattern (LBP) Operator

The local binary pattern (LBP) operator transforms an image into an array, or to an image with integer labels. Integer labels describe small-scale view of the image. For grayscale images, these labels represent a texture descriptor of the image. Integer labels statistics are used for image analysis. Changes of the monotonic gray level do not affect the LBP operator.

Intel® IPP functions described in this section use LBP operators with mask size 3x3 and 5x5.

The \(LBPImage\) functions support four modes of LBP calculation set by the `mode` parameter. The \(LBPImage\) functions compute LBP similar to the \(LBPImageMode\) functions with the `mode` value equal to 1.

The LBP operator with 3x3 mask uses neighborhood consisting of eight pixels, as shown in the figures below.

\[
\sum_{l=1}^{k} (p_{src}[i+y_l, j+x_l] - p_{src}[i+y_u, j+x_u])w_l
\]

\[
\sum_{l=1}^{k} (p_{tilt}[i+y_l, j+x_l] - p_{tilt}[i+y_u, j+x_u])w_l
\]
The LBP operator with 5x5 mask uses neighborhood consisting of 16 pixels, as shown in the figures below.

### mode=1:

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<th>8</th>
<th>7</th>
</tr>
</thead>
<tbody>
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<td>A</td>
<td>6</td>
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<tr>
<td>4</td>
<td>5</td>
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</table>

### mode=2:

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</thead>
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<td>A</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

### mode=3:

<table>
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<tr>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
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<td>A</td>
<td>5</td>
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<tr>
<td>8</td>
<td>7</td>
<td>6</td>
</tr>
</tbody>
</table>
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<th>14</th>
<th>13</th>
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<tbody>
<tr>
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<td>1</td>
<td>6</td>
<td>0</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>A</td>
<td>0</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>0</td>
<td>8</td>
<td>9</td>
<td></td>
</tr>
<tr>
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<td>6</td>
<td>7</td>
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<td></td>
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</tr>
</thead>
<tbody>
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<td>0</td>
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</tr>
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### mode=3:

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<td>4</td>
<td>5</td>
<td>6</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
In the above figures:

- Numbers indicate the position of the corresponding bit in a resulting label
- The A letter indicates the anchor point position.

The LBP operator does the following when processing an image:

- Compares each pixel neighboring to the anchor with the anchor pixel in accordance with the neighboring pixel order. If the neighboring pixel value is more than, or equal to the anchor point value, the result is 1. If the neighboring pixel value is less than the anchor point value, the result is 0.
- Puts the result of comparison to the corresponding bit of the resulting label, as shown in the figure below.

**LBPImageMode**

*Calculates LBP of the image according to the specified mode.*

**Syntax**

```c
IppStatus ippiLBPImageMode3x3_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep,
Ipp<dstDatatype>* pDst, int dstStep, IppiSize dstRoiSize, int mode, IppiBorderType borderType, const Ipp<srcDatatype>* borderValue);
```

Supported values for `mod`:

- 8u_C1R
- 32f8u_C1R

```c
IppStatus ippiLBPImageMode5x5_<mod>(const Ipp<srcDatatype>* pSrc, int srcStep,
Ipp<dstDatatype>* pDst, int dstStep, IppiSize dstRoiSize, int mode, IppiBorderType borderType, const Ipp<srcDatatype>* borderValue);
```
Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

$pSrc$  Pointer to the source image ROI.

$srcStep$  Distance, in bytes, between the starting points of consecutive lines in the source image.

$pDst$  Pointer to the destination image ROI.

$dstStep$  Distance, in bytes, between the starting points of consecutive lines in the destination image.

$dstRoiSize$  Size of the destination ROI, in pixels.

$mode$  Mode for LBP calculation. Supported values are 0, 1, 2, 3.

$borderType$  Type of border. Possible values are:

  * ippBorderRepl  Border is replicated from the edge pixels.
  * ippBorderInMem  Border is obtained from the source image pixels in memory.

  Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderRepl and ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight.

$borderValue$  Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

Description

These functions operate with ROI (see Regions of Interest in Intel IPP).

The ippiLBPImageMode3x3 and ippiLBPImageMode5x5 functions calculate LBP of the $pSrc$ image ROI according to the $mode$ value. The result is stored in the $pDst$ destination image.

Return Values

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error when one of the specified pointers is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error if $dstRoiSize$ has a field with a zero or negative value.</td>
</tr>
<tr>
<td>ippStsBadArgErr</td>
<td>Indicates an error when $border$ has an illegal value.</td>
</tr>
</tbody>
</table>
Example
To better understand usage of the ippiLBPI mageMode function, refer to the LBPI mageMode.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

See Also
Regions of Interest in Intel IPP
LBPI mageHorizCorr
Calculates a correlation between two LBPs.

Syntax
IppStatus ippiLBPI mageHorizCorr_<mod>(const Ipp<datatype>* pSrc1, int src1Step, const Ipp<datatype>* pSrc2, int src2Step, Ipp<datatype>* pDst, int dstStep, IppiSize dstRoiSize, int horShift, IppiBorderType borderType, const Ipp<datatype>* borderValue);

Supported values for mod:
8u_C1R 16u_C1R

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pSrc1, pSrc2
src1Step, src2Step

Pointers to the source image ROI.
Distance, in bytes, between the starting points of consecutive lines in the source image.

pDst
dstStep
dstRoiSize
horShift
borderType

Pointer to the destination image ROI.
Distance, in bytes, between the starting points of consecutive lines in the destination image.
Size of the destination ROI in pixels.
Horizontal shift of the pSrc2 image.
Type of border. Possible values are:
ippBorderRepl Border is replicated from the edge pixels.
ippBorderInMem Border is obtained from the source image pixels in memory.

Mixed borders are also supported. They can be obtained by the bitwise operation OR between ippBorderRepl and ippBorderInMemTop, ippBorderInMemBottom, ippBorderInMemLeft, ippBorderInMemRight.
**borderValue**

Constant value to assign to pixels of the constant border. This parameter is applicable only to the ippBorderConst border type.

**Description**

This function operates with ROI.

This function calculates the difference between two LBP images. The result is stored in the pDst destination image.

**Return Values**

- ippStsNoErr: Indicates no error.
- ippStsNullPtrErr: Indicates an error when one of the specified pointers is NULL.
- ippStsSizeErr: Indicates an error if dstRoiSize has a field with zero or negative value.
- ippStsBadArgErr: Indicates an error when border has an illegal value.

**Example**

To better understand usage of the ippiLBPImageHorizCorr function, refer to the LBPImageHorizCorr.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

**See Also**

- Regions of Interest in Intel IPP
- Borders in Neighborhood Operations
- User-defined Border Types

**Camera Calibration and 3D Reconstruction**

**Correction of Camera Lens Distortion**

Digital camera usually introduces significant distortion caused by the camera and lens. These distortions cause errors in any analysis of the image. The functions described in this section correct these distortion using intrinsic camera parameters and distortion coefficients. These intrinsic camera parameters are focal lengths $fx$, $fy$, and principal point coordinates $cx$, $cy$. The distortion is characterized by two coefficients of radial distortions $k_1$, $k_2$ and two coefficients of tangential distortions $p_1$, $p_2$.

The undistorted coordinates $x_u$ and $y_u$ of point with coordinates $(x_d, y_d)$ are computed in accordance with the following formulas:

$$x_u = x_d \cdot \left(1 + k_1 r^2 + k_2 r^4 \right) + 2 p_1 x_d y_d + p_2 \cdot \left(r^2 + 2x_d^2\right)$$

$$y_u = y_d \cdot \left(1 + k_1 r^2 + k_2 r^4 \right) + 2 p_2 x_d y_d + p_1 \cdot \left(r^2 + 2y_d^2\right)$$

Here $r^2 = x_d^2 + y_d^2$, $x_d = (j-cx)/fx$, $y_d = (i-cy)/fy$; $i$ and $j$ are row and columns numbers of the pixel. The pixel value is computed using bilinear interpolation of four nearest pixel of the source image. If undistorted coordinates are outside the image, then the destination pixel is not changed.
**UndistortGetSize**  
*Computes the size of the external buffer.*

**Syntax**

```c
IppStatus ippiUndistortGetSize(IppiSize roiSize, int* pBufferSize);
```

**Include Files**

ippcv.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h  
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

**Parameters**

- `roiSize`  
  Size of source and destination images ROI in pixels.
- `pBufferSize`  
  Pointer to the computed value of the buffer size.

**Description**

This function computes the size of the temporary external buffer that is used by the functions `ippiUndistortRadial`. The buffer of the computed size can be used to process smaller images as well.

**Return Values**

- `ippStsNoErr`  
  Indicates no error.
- `ippStsNullPtrErr`  
  Indicates an error if `pBufferSize` is NULL.
- `ippStsSizeErr`  
  Indicates an error condition if `roiSize` has a field with zero or negative value.

**UndistortRadial**  
*Corrects radial distortions of the single image.*

**Syntax**

```c
IppStatus ippiUndistortRadial_<mod>(const Ipp<datatype>* pSrc, int srcStep,
                                   Ipp<datatype>* pDst, int dstStep, IppiSize roiSize, Ipp32f fx, Ipp32f fy,
                                   Ipp32f cx, Ipp32f cy, Ipp32f k1, Ipp32f k2, Ipp8u* pBuffer);
```

**Supported values for mod:**

- 8u_C1R  
- 16u_C1R  
- 32f_C1R  
- 8u_C3R  
- 16u_C3R  
- 32f_C3R

**Include Files**

ippcv.h

**Domain Dependencies**

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h  
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib
Parameters

- **pSrc**: Pointer to the ROI in the source distorted image.
- **srcStep**: Distance in bytes between starts of consecutive lines in the source image.
- **pDst**: Pointer to the ROI in the destination corrected image.
- **dstStep**: Distance in bytes between starts of consecutive lines in the destination image.
- **roiSize**: Size of source and destination images ROI in pixels.
- **fx**: Focal lengths along the x axis.
- **fy**: Focal lengths along the y axis.
- **cx**: x-coordinate of the principal point.
- **cy**: y-coordinate of the principal point.
- **k1**: First coefficient of radial distortion.
- **k2**: Second coefficient of radial distortion.
- **pBuffer**: Pointer to the external buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function corrects radial distortions of the single source image `pSrc` and stores corrected image in the `pDst`. Correction is performed accounting camera parameters `fx`, `fy`, `cx`, `cy` and radial distortion parameters `k1`, `k2`. The function can also pass the pointer to the external buffer `pBuffer` whose size should be computed previously using the function `ippiUndistortGetSize`. If a null pointer is passed, slower computations without an external buffer will be performed.

Return Values

- **ippStsNoErr**: Indicates no error.
- **ippStsNullPtrErr**: Indicates an error if `pSrc` or `pDst` is NULL.
- **ippStsSizeErr**: Indicates an error condition if `roiSize` has a field with zero or negative value.
- **ippStsStepErr**: Indicates an error condition if `srcStep` is less than `roiSize.width * <pixelSize>`, or `dstStep` is less than `roiSize.width * <pixelSize>`.
- **ippStsNotEvenStepErr**: Indicates an error condition if one of the step values is not divisible by 4 for floating-point images, or by 2 for short-integer images.
- **ippStsBadArgErr**: Indicates an error if `fx` or `fy` is equal to 0.

CreateMapCameraUndistort

_Creates look-up tables of coordinates of corrected image._
Syntax

IppStatusippiCreateMapCameraUndistort_32f_C1R(Ipp32f* pxMap, int xStep, Ipp32f* pyMap, int yStep, IppiSize roiSize, Ipp32f fx, Ipp32f fy, Ipp32f cx, Ipp32f cy, Ipp32f k1, Ipp32f k2, Ipp32f p1, Ipp32f p2, Ipp8u* pBuffer);

Include Files

ippcv.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h,ippi.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib,ippi.lib

Parameters

pxMap  
Pointer to the destination x coordinate look-up buffer.

xStep  
Distance in bytes between starts of consecutive lines in the pxMap image.

pyMap  
Pointer to the destination y coordinate look-up buffer.

yStep  
Distance in bytes between starts of consecutive lines in the pyMap image.

roiSize  
Size of source and destination images ROI in pixels.

fx  
Focal lengths along the x axis.

fy  
Focal lengths along the y axis.

cx  
x-coordinate of the principal point.

cy  
y-coordinate of the principal point.

k1  
First coefficient of radial distortion.

k2  
Second coefficient of radial distortion.

p1  
First coefficient of tangential distortion.

p2  
Second coefficient of tangential distortion.

pBuffer  
Pointer to the external buffer.

Description

This function operates with ROI (see Regions of Interest in Intel IPP).

This function creates the look-up tables of x- and y-coordinates pxMap and pyMap respectively. These coordinates are computed in accordance with camera parameters fx, fy, cx, cy, and distortion parameters k1, k2, p1, p2. The created tables can be used by the Intel IPP functionippiRemap to remap the distorted source image and get the corrected image.

To accelerate the computations the function can pass the pointer to the external buffer pBuffer whose size should be computed previously using the functionippiUndistortGetSize. If a null pointer is passed, slower computations without an external buffer will be performed.

Return Values

ippStsNoErr  
Indicates no error.
ippStsNullPtrErr  Indicates an error if pxMap or pyMap is NULL.

ippStsSizeErr  Indicates an error condition if roiSize has a field with zero or negative value.

ippStsStepErr  Indicates an error condition if: xStep is less than roiSize.width * <pixelSize>, or yStep is less than roiSize.width * <pixelSize>.

ippStsNotEvenStepErr  Indicates an error condition if one of the step values is not divisible by 4 for floating-point images.

ippStsBadArgErr  Indicates an error when fx or fy is equal to 0.

**Example**

To better understand usage of the ippiCreateMapCameraUndistort function, refer to the CreateMapCameraUndistort.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.
3D Data Processing Functions

This section describes the Intel® Integrated Performance Primitives (Intel® IPP) functions that perform 3D data transforms - resizing, affine transform, and remapping, as well as functions for 3D data linear filtering.

CopyConstBorder

Copies pixel values between two 3D images and adds border pixels with a constant value.

Syntax

IppStatus ipprCopyConstBorder_8u_C1V(const Ipp8u* pSrc, int srcPlaneStep, int srcStep, IpprVolume srcRoiVolume, Ipp8u* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, int topBorderHeight, int leftBorderWidth, int forwardBorderDepth, const Ipp8u* value);

IppStatus ipprCopyConstBorder_16u_C1V(const Ipp16u* pSrc, int srcPlaneStep, int srcStep, IpprVolume srcRoiVolume, Ipp16u* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, int topBorderHeight, int leftBorderWidth, int forwardBorderDepth, const Ipp16u* value);

IppStatus ipprCopyConstBorder_16s_C1V(const Ipp16s* pSrc, int srcPlaneStep, int srcStep, IpprVolume srcRoiVolume, Ipp16s* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, int topBorderHeight, int leftBorderWidth, int forwardBorderDepth, const Ipp16s* value);

IppStatus ipprCopyConstBorder_32f_C1V(const Ipp32f* pSrc, int srcPlaneStep, int srcStep, IpprVolume srcRoiVolume, Ipp32f* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, int topBorderHeight, int leftBorderWidth, int forwardBorderDepth, const Ipp32f* value);

IppStatus ipprCopyConstBorder_64f_C1V(const Ipp64f* pSrc, int srcPlaneStep, int srcStep, IpprVolume srcRoiVolume, Ipp64f* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, int topBorderHeight, int leftBorderWidth, int forwardBorderDepth, const Ipp64f* value);

Platform-aware functions


IppStatus ipprCopyConstBorder_16s_C1V_L(const Ipp16s* pSrc, IppSizeL srcPlaneStep, IppSizeL srcStep, IpprVolumeL srcRoiVolume, Ipp16s* pDst, IppSizeL dstPlaneStep, IppSizeL dstStep, IpprVolumeL dstRoiVolume, IppSizeL topBorderHeight, IppSizeL leftBorderWidth, IppSizeL forwardBorderDepth, const Ipp16s* value);

IppStatus ipprCopyConstBorder_64f_C1V_L(const Ipp64f* pSrc, IppSizeL srcPlaneStep, IppSizeL srcStep, IppVolumeL srcRoiVolume, Ipp64f* pDst, IppSizeL dstPlaneStep, IppSizeL dstStep, IppVolumeL dstRoiVolume, IppSizeL topBorderHeight, IppSizeL leftBorderWidth, IppSizeL forwardBorderDepth, const Ipp64f* value);

Include Files
ippi.h
ippi_l.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pSrc
srcStep
srcPlaneStep
srcRoiVolume
pDst
dstStep
dstPlaneStep
dstRoiVolume
topBorderHeight
leftBorderWidth
forwardBorderDepth
value

Array of pointers to the planes in the source volume.
Distance, in bytes, between the starting points of consecutive lines in each plane of the source volume.
Distance, in bytes, between the starting points of consecutive images in every plane of the source volume.
Volume of the source ROI in pixels.
Array of pointers to the planes in the destination volume.
Distance, in bytes, between the starting points of consecutive lines in each plane of the destination volume.
Distance, in bytes, between the starting points of consecutive images in every plane of the source volume.
Volume of the destination ROI in pixels.
Height of the top border in pixels.
Width of the left border in pixels.
Depth of the forward border in pixels.
Constant value to assign to the border pixels.

Description
This function operates with VOI. This function copies the source image pSrc with the volume srcRoiVolume to the destination image pDst with the volume dstRoiVolume and creates a border outside the copied area. The function sets pixel values of the border to the specified constant value that is passed by the value argument.
The image below shows the mapping of the parameters topBorderHeight, leftBorderWidth, and forwardBorderDepth onto the dimensions of the three-dimensional space.
Return Values

ippStsNullPtrErr  Indicates an error condition if pSrc, pDst, or value pointer is NULL.

ippStsStepErr  Indicates an error condition if srcPlaneStep, srcStep, dstPlaneStep, or dstStep has a field with negative value.

ippStsSizeErr  Indicates an error condition if leftBorderWidth, topBorderHeight, or forwardBorderDepth has a field with negative value.

See Also

CopyReplicateBorder  Copies pixel values between two 3D images and adds replicated border pixels.

Structures and Enumerators for Platform-Aware Functions

CopyReplicateBorder

Copies pixel values between two 3D images and adds replicated border pixels.

Syntax

IppStatus ipprCopyReplicateBorder_8u_C1V(const Ipp8u* pSrc, int srcPlaneStep, int srcStep, IpprVolume srcRoiVolume, Ipp8u* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, int topBorderHeight, int leftBorderWidth, int forwardBorderDepth);

IppStatus ipprCopyReplicateBorder_16u_C1V(const Ipp16u* pSrc, int srcPlaneStep, int srcStep, IpprVolume srcRoiVolume, Ipp16u* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, int topBorderHeight, int leftBorderWidth, int forwardBorderDepth);

IppStatus ipprCopyReplicateBorder_16s_C1V(const Ipp16s* pSrc, int srcPlaneStep, int srcStep, IpprVolume srcRoiVolume, Ipp16s* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, int topBorderHeight, int leftBorderWidth, int forwardBorderDepth);
IppStatus ipprCopyReplicateBorder_32f_C1V(const Ipp32f* pSrc, int srcPlaneStep, int srcStep, IpprVolume srcRoiVolume, Ipp32f* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, int topBorderHeight, int leftBorderWidth, int forwardBorderDepth);

IppStatus ipprCopyReplicateBorder_64f_C1V(const Ipp64f* pSrc, int srcPlaneStep, int srcStep, IpprVolume srcRoiVolume, Ipp64f* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, int topBorderHeight, int leftBorderWidth, int forwardBorderDepth);

Platform-aware functions


IppStatus ipprCopyReplicateBorder_64f_C1V_L(const Ipp64f* pSrc, IppSizeL srcPlaneStep, IppSizeL srcStep, IpprVolumeL srcRoiVolume, Ipp64f* pDst, IppSizeL dstPlaneStep, IppSizeL dstStep, IpprVolumeL dstRoiVolume, IppSizeL topBorderHeight, IppSizeL leftBorderWidth, IppSizeL forwardBorderDepth);

Include Files

ippi.h
ippi_l.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc
srcStep
srcPlaneStep
srcRoiVolume
pDst

dstPlaneStep

dstStep

daRoiVolume

topBorderHeight

Array of pointers to the planes in the source volume.
Distance, in bytes, between the starting points of consecutive
lines in each plane of the source volume.
Distance, in bytes, between the starting points of consecutive
images in every plane of the source volume.
Volume of the source ROI in pixels.
Array of pointers to the planes in the destination volume.
**dstStep**
Distance, in bytes, between the starting points of consecutive lines in each plane of the destination volume.

**dstPlaneStep**
Distance, in bytes, between the starting points of consecutive images in every plane of the source volume.

**dstRoiVolume**
Volume of the destination ROI in pixels.

**topBorderHeight**
Height of the top border in pixels.

**leftBorderWidth**
Width of the left border in pixels.

**forwardBorderDepth**
Depth of the forward border in pixels.

### Description
This function operates with VOI. This function copies the source image `pSrc` with the volume `srcRoiVolume` to the destination image `pDst` with the volume `dstRoiVolume`. The function fills pixels ('border') outside the copied area in the destination image with the values of the source image pixels.

The image below shows the mapping of the parameters `topBorderHeight`, `leftBorderWidth`, and `forwardBorderWidth` onto the dimensions of the three-dimensional space.

### Return Values

**ippStsNullPtrErr**
Indicates an error condition if `pSrc` or `pDst` pointer is NULL.

**ippStsStepErr**
Indicates an error condition if `srcPlaneStep` value is less than `srcStep` value or if `dstPlaneStep` value is less than `dstStep` value.

**ippStsSizeErr**
Indicates an error condition if `leftBorderWidth`, `topBorderHeight` or `forwardBorderDepth` has a field with negative value.

### See Also
**CopyConstBorder**
Copies pixel values between two 3D images and adds border pixels with a constant value.

**Structures and Enumerators for Platform-Aware Functions**
Filter
Filters a volume using a general cuboidal kernel.

Syntax
IppStatus ipprFilter_16s_C1PV(const Ipp16s* const pSrc[], int srcStep, const Ipp16s* pDst[], int dstStep, IpprVolume dstVolume, const Ipp32s* pKernel, IpprVolume kernelVolume, IpprPoint anchor, int divisor, Ipp8u* pBuffer);
IppStatus ipprFilter_16s_C1V(const Ipp16s* pSrc, int srcStep, int srcPlaneStep, Ipp16s* pDst, int dstStep, int dstPlaneStep, IpprVolume dstVolume, const Ipp32s* pKernel, IpprVolume kernelVolume, IpprPoint anchor, int divisor, Ipp8u* pBuffer);

Include Files
ippi.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters
pSrc
srcStep
srcPlaneStep
pDst
dstStep
dstPlaneStep
dstVolume
pKernel
kernelVolume
anchor
divisor
pBuffer

Description
This function operates with VOI. This function uses the general cuboidal kernel of size kernelVolume to filter a volume VOI. This function sums the products between the kernel coefficients pKernel and voxel values taken over the source voxel neighborhood defined by kernelVolume and anchor. The anchor 3d-cell is specified by its coordinates anchor.x, anchor.y and anchor.z in the coordinate system associated with the

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right bottom back corner of the kernel. Note the kernel coefficients are used in inverse order. The sum is written to the destination voxel. To ensure valid operation when volume boundary voxels are processed, the application must correctly define additional border voxels.

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error.

- **ippStsNullPtrErr**
  Indicates an error condition if `pSrc`, `pDst`, `pKernel` or `pBuffer` pointer is NULL.

- **ippStsSizeErr**
  Indicates an error condition if `dstVolume` or `kernelVolume` has a field with zero or negative value.

- **ippStsDivisorErr**
  Indicates an error condition if the divisor value is zero.

### FilterGetBufSize

*Calculates the size of the working buffer.*

**Syntax**

```c
IppStatus ipprFilterGetBufSize(IpprVolume dstVolume, IpprVolume kernelVolume, int nChannel, int* pSize);
```

**Include Files**

`ippi.h`

**Domain Dependencies**

- **Headers**: `ippcore.h`, `ippvm.h`, `ipps.h`
- **Libraries**: `ippcore.lib`, `ippvm.lib`, `ipps.lib`

**Parameters**

- **dstVolume**
  Size of the processed volume.

- **kernelVolume**
  Size of the kernel volume.

- **nChannel**
  Number of channels or planes, possible value is one.

- **pSize**
  Pointer to the size of the external buffer.

**Description**

This function operates with VOI. This function computes the size of the working buffer `pSize` that is required for the function `ipprFilter`.

**Return Values**

- **ippStsNoErr**
  Indicates no error. Any other value indicates an error.

- **ippStsNullPtrErr**
  Indicates an error condition if `pSize` pointer is NULL.

- **ippStsNumChannelErr**
  Indicates an error condition if `nChannel` has an illegal value.

- **ippStsSizeErr**
  Indicates an error condition if `dstVolume` or `kernelVolume` has a field with zero or negative value.
FilterBorder

*Filters a 3D image using a rectangular filter.*

**Syntax**

```
IppStatus ipprFilterBorder_8u_C1V(const Ipp8u* pSrc, int srcPlaneStep, int srcStep, Ipp8u* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, IpprBorderType borderType, const Ipp8u borderValue[1], const IpprFilterBorderSpec* pSpec, Ipp8u* pBuffer);
```

```
IppStatus ipprFilterBorder_16s_C1V(const Ipp16s* pSrc, int srcPlaneStep, int srcStep, Ipp16s* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, IpprBorderType borderType, const Ipp16s borderValue[1], const IpprFilterBorderSpec* pSpec, Ipp8u* pBuffer);
```

```
IppStatus ipprFilterBorder_16u_C1V(const Ipp16u* pSrc, int srcPlaneStep, int srcStep, Ipp16u* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, IpprBorderType borderType, const Ipp16u borderValue[1], const IpprFilterBorderSpec* pSpec, Ipp8u* pBuffer);
```

```
IppStatus ipprFilterBorder_32f_C1V(const Ipp32f* pSrc, int srcPlaneStep, int srcStep, Ipp32f* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, IpprBorderType borderType, const Ipp32f borderValue[1], const IpprFilterBorderSpec* pSpec, Ipp8u* pBuffer);
```

```
IppStatus ipprFilterBorder_64f_C1V(const Ipp64f* pSrc, int srcPlaneStep, int srcStep, Ipp64f* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, IpprBorderType borderType, const Ipp64f borderValue[1], const IpprFilterBorderSpec* pSpec, Ipp8u* pBuffer);
```

**Platform-aware functions**

```
IppStatus ipprFilterBorder_8u_C1V_L(const Ipp8u* pSrc, IppSizeL srcPlaneStep, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstPlaneStep, IppSizeL dstStep, IpprVolumeL dstRoiVolume, IpprBorderType borderType, const Ipp8u borderValue[1], const IpprFilterBorderSpec* pSpec, Ipp8u* pBuffer);
```

```
IppStatus ipprFilterBorder_16s_C1V_L(const Ipp16s* pSrc, IppSizeL srcPlaneStep, IppSizeL srcStep, Ipp16s* pDst, IppSizeL dstPlaneStep, IppSizeL dstStep, IpprVolumeL dstRoiVolume, IpprBorderType borderType, const Ipp16s borderValue[1], const IpprFilterBorderSpec* pSpec, Ipp8u* pBuffer);
```

```
IppStatus ipprFilterBorder_16u_C1V_L(const Ipp16u* pSrc, IppSizeL srcPlaneStep, IppSizeL srcStep, Ipp16u* pDst, IppSizeL dstPlaneStep, IppSizeL dstStep, IpprVolumeL dstRoiVolume, IpprBorderType borderType, const Ipp16u borderValue[1], const IpprFilterBorderSpec* pSpec, Ipp8u* pBuffer);
```

```
IppStatus ipprFilterBorder_32f_C1V_L(const Ipp32f* pSrc, IppSizeL srcPlaneStep, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstPlaneStep, IppSizeL dstStep, IpprVolumeL dstRoiVolume, IpprBorderType borderType, const Ipp32f borderValue[1], const IpprFilterBorderSpec* pSpec, Ipp8u* pBuffer);
```

```
IppStatus ipprFilterBorder_64f_C1V_L(const Ipp64f* pSrc, IppSizeL srcPlaneStep, IppSizeL srcStep, Ipp64f* pDst, IppSizeL dstPlaneStep, IppSizeL dstStep, IpprVolumeL dstRoiVolume, IpprBorderType borderType, const Ipp64f borderValue[1], const IpprFilterBorderSpec* pSpec, Ipp8u* pBuffer);
```
Threading Layer (TL) functions based on the Platform Aware API

IppStatus ipprFilterBorder_8u_C1V_LT(const Ipp8u* pSrc, IppSizeL srcPlaneStep, IppSizeL srcStep, Ipp8u* pDst, IppSizeL dstPlaneStep, IppSizeL dstStep, IpprVolumeL dstRoiVolume, IpprBorderType borderType, const Ipp8u borderValue[1], const IpprFilterBorderSpec_LT* pSpec, Ipp8u* pBuffer);

IppStatus ipprFilterBorder_16s_C1V_LT(const Ipp16s* pSrc, IppSizeL srcPlaneStep, IppSizeL srcStep, Ipp16s* pDst, IppSizeL dstPlaneStep, IppSizeL dstStep, IpprVolumeL dstRoiVolume, IpprBorderType borderType, const Ipp16s borderValue[1], const IpprFilterBorderSpec_LT* pSpec, Ipp8u* pBuffer);

IppStatus ipprFilterBorder_16u_C1V_LT(const Ipp16u* pSrc, IppSizeL srcPlaneStep, IppSizeL srcStep, Ipp16u* pDst, IppSizeL dstPlaneStep, IppSizeL dstStep, IpprVolumeL dstRoiVolume, IpprBorderType borderType, const Ipp16u borderValue[1], const IpprFilterBorderSpec_LT* pSpec, Ipp8u* pBuffer);

IppStatus ipprFilterBorder_32f_C1V_LT(const Ipp32f* pSrc, IppSizeL srcPlaneStep, IppSizeL srcStep, Ipp32f* pDst, IppSizeL dstPlaneStep, IppSizeL dstStep, IpprVolumeL dstRoiVolume, IpprBorderType borderType, const Ipp32f borderValue[1], const IpprFilterBorderSpec_LT* pSpec, Ipp8u* pBuffer);

IppStatus ipprFilterBorder_64f_C1V_LT(const Ipp64f* pSrc, IppSizeL srcPlaneStep, IppSizeL srcStep, Ipp64f* pDst, IppSizeL dstPlaneStep, IppSizeL dstStep, IpprVolumeL dstRoiVolume, IpprBorderType borderType, const Ipp64f borderValue[1], const IpprFilterBorderSpec_LT* pSpec, Ipp8u* pBuffer);

Threading Layer (TL) functions based on the Classic API

IppStatus ipprFilterBorder_8u_C1V_T(const Ipp8u* pSrc, int srcPlaneStep, int srcStep, Ipp8u* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, IpprBorderType borderType, const Ipp8u borderValue[1], const IpprFilterBorderSpec_T* pSpec, Ipp8u* pBuffer);

IppStatus ipprFilterBorder_16s_C1V_T(const Ipp16s* pSrc, int srcPlaneStep, int srcStep, Ipp16s* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, IpprBorderType borderType, const Ipp16s borderValue[1], const IpprFilterBorderSpec_T* pSpec, Ipp8u* pBuffer);

IppStatus ipprFilterBorder_16u_C1V_T(const Ipp16u* pSrc, int srcPlaneStep, int srcStep, Ipp16u* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, IpprBorderType borderType, const Ipp16u borderValue[1], const IpprFilterBorderSpec_T* pSpec, Ipp8u* pBuffer);

IppStatus ipprFilterBorder_32f_C1V_T(const Ipp32f* pSrc, int srcPlaneStep, int srcStep, Ipp32f* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, IpprBorderType borderType, const Ipp32f borderValue[1], const IpprFilterBorderSpec_T* pSpec, Ipp8u* pBuffer);

IppStatus ipprFilterBorder_64f_C1V_T(const Ipp64f* pSrc, int srcPlaneStep, int srcStep, Ipp64f* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, IpprBorderType borderType, const Ipp64f borderValue[1], const IpprFilterBorderSpec_T* pSpec, Ipp8u* pBuffer);

Include Files

ippi.h
ippi_l.h
ippi_tl.h
Domain Dependencies
Headers: ippcore.h, ippvm.h, ipp.h
Libraries: ippcore.lib, ippvm.lib, ipp.lib

Parameters

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<tbody>
<tr>
<td>pSrc</td>
<td>Array of pointers to the planes in the source volume.</td>
</tr>
<tr>
<td>srcStep</td>
<td>Distance, in bytes, between the starting points of consecutive lines in each plane of the source volume.</td>
</tr>
<tr>
<td>srcPlaneStep</td>
<td>Distance, in bytes, between the starting points of consecutive images in every plane of the source volume.</td>
</tr>
<tr>
<td>pDst</td>
<td>Array of pointers to the planes in the destination volume.</td>
</tr>
<tr>
<td>dstStep</td>
<td>Distance, in bytes, between the starting points of consecutive lines in each plane of the destination volume.</td>
</tr>
<tr>
<td>dstPlaneStep</td>
<td>Distance, in bytes, between the starting points of consecutive images in every plane of the source volume.</td>
</tr>
<tr>
<td>dstRoiVolume</td>
<td>Volume of the destination ROI in pixels.</td>
</tr>
<tr>
<td>borderType</td>
<td>Type of the border. Possible values are:</td>
</tr>
<tr>
<td></td>
<td>ipprBorderInMem  Border is obtained from the source image pixels in memory.</td>
</tr>
<tr>
<td></td>
<td>ipprBorderRepl   Border is replicated from the edge pixels.</td>
</tr>
<tr>
<td></td>
<td>ipprBorderConst  Border is replicated from the edge pixels.</td>
</tr>
<tr>
<td>borderValue</td>
<td>Constant value to assign to pixels of the constant border.</td>
</tr>
<tr>
<td>pSpec</td>
<td>Pointer to the filter specification structure.</td>
</tr>
<tr>
<td>pBuffer</td>
<td>Pointer to the work buffer for filtering operations.</td>
</tr>
</tbody>
</table>

Description
Before using this function, you need to initialize the filter specification structure for 3D image processing using the ipprFilterBorderInit function.

This function operates with VOI. This function performs linear filtering on a source image with the volume. Type of the image border is defined by the value of the border parameter.

Return Values

<table>
<thead>
<tr>
<th>Return Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippStsNoErr</td>
<td>Indicates no error condition. Any other value indicates an error condition.</td>
</tr>
<tr>
<td>ippStsStepErr</td>
<td>Indicates an error condition if srcPlaneStep, srcStep, dstPlaneStep, or dstStep has a field with negative value.</td>
</tr>
<tr>
<td>ippStsNullPtrErr</td>
<td>Indicates an error condition if the pSrc, pDst, pSpec, or pBuffer pointer is NULL.</td>
</tr>
<tr>
<td>ippStsSizeErr</td>
<td>Indicates an error condition if dstRoiVolume has a field with zero or negative value.</td>
</tr>
</tbody>
</table>
Example
To better understand usage of this function, refer to the FilterBorder3d.c example in the examples archive available for download from https://software.intel.com/en-us/ipp-manual-examples.

See Also
FilterBorderInit  Initializes the filter specification structure for 3D image processing.
FilterBorderGetSize  Computes the size of the filter specification structure and the size of the work buffer for 3D image processing.

Structures and Enumerators
Structures and Enumerators for Platform-Aware Functions

**FilterBorderInit**

*Initializes the filter specification structure for 3D image processing.*

**Syntax**

IppStatus ipprFilterBorderInit_16s(const Ipp16s* pKernel, IpprVolume kernelVolume, int divisor, IppDataType dataType, int numChannels, IpprFilterBorderSpec* pSpec);
IppStatus ipprFilterBorderInit_32f(const Ipp32f* pKernel, IpprVolume kernelVolume, IppDataType dataType, int numChannels, IpprFilterBorderSpec* pSpec);
IppStatus ipprFilterBorderInit_64f(const Ipp64f* pKernel, IpprVolume kernelVolume, IppDataType dataType, int numChannels, IpprFilterBorderSpec* pSpec);

**Platform-aware functions**

IppStatus ipprFilterBorderInit_16s_L(const Ipp16s* pKernel, IpprVolumeL kernelVolume, int divisor, IppDataType dataType, int numChannels, IpprFilterBorderSpec* pSpec);
IppStatus ipprFilterBorderInit_32f_L(const Ipp32f* pKernel, IpprVolumeL kernelVolume, IppDataType dataType, int numChannels, IpprFilterBorderSpec* pSpec);
IppStatus ipprFilterBorderInit_64f_L(const Ipp64f* pKernel, IpprVolumeL kernelVolume, IppDataType dataType, int numChannels, IpprFilterBorderSpec* pSpec);

**Threading Layer (TL) functions based on the Platform Aware API**

IppStatus ipprFilterBorderInit_16s_LT(const Ipp16s* pKernel, IpprVolumeL kernelVolume, int divisor, IppDataType dataType, int numChannels, IpprFilterBorderSpec_LT* pSpec);
IppStatus ipprFilterBorderInit_32f_LT(const Ipp32f* pKernel, IpprVolumeL kernelVolume, IppDataType dataType, int numChannels, IpprFilterBorderSpec_LT* pSpec);
IppStatus ipprFilterBorderInit_64f_LT(const Ipp64f* pKernel, IpprVolumeL kernelVolume, IppDataType dataType, int numChannels, IpprFilterBorderSpec_LT* pSpec);

**Threading Layer (TL) functions based on the Classic API**

IppStatus ipprFilterBorderInit_16s_T(const Ipp16s* pKernel, IpprVolume kernelVolume, int divisor, IppDataType dataType, int numChannels, IpprFilterBorderSpec_T* pSpec);
IppStatus ipprFilterBorderInit_32f_T(const Ipp32f* pKernel, IpprVolume kernelVolume, IppDataType dataType, int numChannels, IpprFilterBorderSpec_T* pSpec);
IppStatus ipprFilterBorderInit_64f_T(const Ipp64f* pKernel, IpprVolume kernelVolume, IppDataType dataType, int numChannels, IpprFilterBorderSpec_T* pSpec);
Include Files
ippi.h
ippi_l.h
ippi_tl.h

Domain Dependencies
Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

kernelVolume  Size of the kernel volume.
pKernel  Pointers to the kernel values.
dataType  Data type of the source image. Possible values are ipp8u, ipp16u, ipp16s, ipp32f, and ipp64f.
divisor  The integer value by which the computed result is divided.
numChannels  Number of channels in the image. Possible value is 1.
pSpec  Pointer to the filter specification structure.

Description
This function operates with VOI. This function initializes the filter specification structure pSpec. Before using this function, you need to compute the size of the specification structure for 3D image processing using the ipprFilterBorderGetSize function.

Return Values

ippStsNoErr  Indicates no error condition. Any other value indicates an error condition.
ippStsNullPtrErr  Indicates an error condition if the pSpec or pKernel pointer is NULL.
ippStsSizeErr  Indicates an error condition if kernelVolume has a field with zero or negative value.
ippStsChannelErr  Indicates an error condition if numChannels has an illegal value.
ippStsDataTypeErr  Indicates an error condition if dataType has an illegal value.
ippStsDivisorErr  Indicates an error condition if the divisor value is zero.

See Also
FilterBorder  Filters a 3D image using a rectangular filter.
FilterBorderGetSize  Computes the size of the filter specification structure and the size of the work buffer for 3D image processing.
Structures and Enumerators for Platform-Aware Functions
FilterBorderGetSize

Computes the size of the filter specification structure and the size of the work buffer for 3D image processing.

Syntax

IppStatus ipprFilterBorderGetSize(IpprVolume kernelVolume, IpprVolume dstRoiVolume, IppDataType dataType, IppDataType kernelType, int numChannels, int* pSpecSize, int* pBufferSize);

Platform-aware function

IppStatus ipprFilterBorderGetSize_L(IpprVolumeL kernelVolume, IpprVolumeL dstRoiVolume, IppDataType dataType, IppDataType kernelType, int numChannels, IppSizeL* pSpecSize, IppSizeL* pBufferSize);

Threading Layer (TL) function based on the Platform Aware API

IppStatus ipprFilterBorderGetSize_LT(IpprVolumeL kernelVolume, IpprVolumeL dstRoiVolume, IppDataType dataType, IppDataType kernelType, int numChannels, IppSizeL* pSpecSize, IppSizeL* pBufferSize);

Threading Layer (TL) function based on the Classic API

IppStatus ipprFilterBorderGetSize_T(IpprVolume kernelVolume, IpprVolume dstRoiVolume, IppDataType dataType, IppDataType kernelType, int numChannels, int* pSpecSize, int* pBufferSize);

Include Files

ippi.h
ippi_l.h
ippi_tl.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

kernelVolume  Size of the kernel volume.
dstRoiVolume  Maximal size of the destination image ROI (in pixels).
dataType  Data type of the source image. Possible values are ipp8u, ipp16u, ipp16s, ipp32f, and ipp64f.
kernelType  Data type of the filter kernel. Possible values are ipp16s, ipp32f, and ipp64f.
umChannels  Number of channels in the image. Possible value is 1.
pSpecSize  Pointer to the size of the filter specification structure.
pBufferSize  Pointer to the size of the work buffer required for filtering.
Description

This function operates with VOI. This function computes the size of the filter specification structure \( pSpec \) and the size of the buffer required for 3D image filtering operations. Call this function before using the \texttt{ipprFilterBorderInit} function.

Return Values

- \texttt{ippStsNoErr}  
  Indicates no error condition. Any other value indicates an error condition.
- \texttt{ippStsNullPtrErr}  
  Indicates an error condition if the \( pSpecSize \) or \( pBufferSize \) pointer is \texttt{NULL}.
- \texttt{ippStsSizeErr}  
  Indicates an error condition if \( dstRoiVolume \) or \( kernelVolume \) has a field with zero or negative value.
- \texttt{ippStsChannelErr}  
  Indicates an error condition if \( numChannels \) has an illegal value.
- \texttt{ippStsDataTypeErr}  
  Indicates an error condition if the combination of \( kernelType \) and \( dataType \) has an illegal value.

See Also

- \texttt{FilterBorder}  
  Filters a 3D image using a rectangular filter.
- \texttt{FilterBorderInit}  
  Initializes the filter specification structure for 3D image processing.
- Structures and Enumerators for Platform-Aware Functions

FilterMedian

_filters a 3D image using a median filter._

Syntax

\[
\text{IppStatus ipprFilterMedian}_\text{8u C1V}(\text{const Ipp8u*} \ pSrc, \ \text{int} \ srcPlaneStep, \ \text{int} \ srcStep, \ \text{Ipp8u*} \ pDst, \ \text{int} \ dstPlaneStep, \ \text{int} \ dstStep, \ \text{IpprVolume} \ dstRoiVolume, \ \text{IpprBorderType} \ borderType, \ \text{const Ipp8u*} \ pBorderValue, \ \text{const IpprFilterMedianSpec*} \ pSpec, \ \text{Ipp8u*} \ pBuffer);
\]

\[
\text{IppStatus ipprFilterMedian}_\text{16u C1V}(\text{const Ipp16u*} \ pSrc, \ \text{int} \ srcPlaneStep, \ \text{int} \ srcStep, \ \text{Ipp16u*} \ pDst, \ \text{int} \ dstPlaneStep, \ \text{int} \ dstStep, \ \text{IpprVolume} \ dstRoiVolume, \ \text{IpprBorderType} \ borderType, \ \text{const Ipp16u*} \ pBorderValue, \ \text{const IpprFilterMedianSpec*} \ pSpec, \ \text{Ipp8u*} \ pBuffer);
\]

\[
\text{IppStatus ipprFilterMedian}_\text{16s C1V}(\text{const Ipp16s*} \ pSrc, \ \text{int} \ srcPlaneStep, \ \text{int} \ srcStep, \ \text{Ipp16s*} \ pDst, \ \text{int} \ dstPlaneStep, \ \text{int} \ dstStep, \ \text{IpprVolume} \ dstRoiVolume, \ \text{IpprBorderType} \ borderType, \ \text{const Ipp16s*} \ pBorderValue, \ \text{const IpprFilterMedianSpec*} \ pSpec, \ \text{Ipp8u*} \ pBuffer);
\]

\[
\text{IppStatus ipprFilterMedian}_\text{32f C1V}(\text{const Ipp32f*} \ pSrc, \ \text{int} \ srcPlaneStep, \ \text{int} \ srcStep, \ \text{Ipp32f*} \ pDst, \ \text{int} \ dstPlaneStep, \ \text{int} \ dstStep, \ \text{IpprVolume} \ dstRoiVolume, \ \text{IpprBorderType} \ borderType, \ \text{const Ipp32f*} \ pBorderValue, \ \text{const IpprFilterMedianSpec*} \ pSpec, \ \text{Ipp8u*} \ pBuffer);
\]

\[
\text{IppStatus ipprFilterMedian}_\text{64f C1V}(\text{const Ipp64f*} \ pSrc, \ \text{int} \ srcPlaneStep, \ \text{int} \ srcStep, \ \text{Ipp64f*} \ pDst, \ \text{int} \ dstPlaneStep, \ \text{int} \ dstStep, \ \text{IpprVolume} \ dstRoiVolume, \ \text{IpprBorderType} \ borderType, \ \text{const Ipp64f*} \ pBorderValue, \ \text{const IpprFilterMedianSpec*} \ pSpec, \ \text{Ipp8u*} \ pBuffer);
\]
Threading Layer (TL) functions

IppStatus ipprFilterMedian_8u_C1V_T(const Ipp8u* pSrc, int srcPlaneStep, int srcStep, Ipp8u* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, IpprBorderType borderType, const Ipp8u* pBorderValue, const IpprFilterMedianSpec_T* pSpec, Ipp8u* pBuffer);

IppStatus ipprFilterMedian_16u_C1V_T(const Ipp16u* pSrc, int srcPlaneStep, int srcStep, Ipp16u* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, IpprBorderType borderType, const Ipp16u* pBorderValue, const IpprFilterMedianSpec_T* pSpec, Ipp8u* pBuffer);

IppStatus ipprFilterMedian_16s_C1V_T(const Ipp16s* pSrc, int srcPlaneStep, int srcStep, Ipp16s* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, IpprBorderType borderType, const Ipp16s* pBorderValue, const IpprFilterMedianSpec_T* pSpec, Ipp8u* pBuffer);

IppStatus ipprFilterMedian_32f_C1V_T(const Ipp32f* pSrc, int srcPlaneStep, int srcStep, Ipp32f* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, IpprBorderType borderType, const Ipp32f* pBorderValue, const IpprFilterMedianSpec_T* pSpec, Ipp8u* pBuffer);

IppStatus ipprFilterMedian_64f_C1V_T(const Ipp64f* pSrc, int srcPlaneStep, int srcStep, Ipp64f* pDst, int dstPlaneStep, int dstStep, IpprVolume dstRoiVolume, IpprBorderType borderType, const Ipp64f* pBorderValue, const IpprFilterMedianSpec_T* pSpec, Ipp8u* pBuffer);


domain

Include Files

ippi.h
ippi_tl.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc
Array of pointers to the planes in the source volume.

srcStep
Distance, in bytes, between the starting points of consecutive lines in each plane of the source volume.

csrcPlaneStep
Distance, in bytes, between the starting points of consecutive images in every plane of the source volume.

pDst
Array of pointers to the planes in the destination volume.

dstStep
Distance, in bytes, between the starting points of consecutive lines in each plane of the destination volume.

dstPlaneStep
Distance, in bytes, between the starting points of consecutive images in every plane of the source volume.

dstRoiVolume
Volume of the destination ROI in pixels.

borderType
Type of the border. Possible values are:
ipprBorderInMem  Border is obtained from the source image pixels in memory.

ipprBorderRepl  Border is replicated from the edge pixels.

ipprBorderConst  Border is replicated from the edge pixels.

pBorderValue  Pointer to the constant value to assign to pixels of the constant border.

pSpec  Pointer to the filter specification structure.

pBuffer  Pointer to the work buffer for filtering operations.

**Description**

Before using this function, you need to initialize the filter specification structure for 3D image processing using the `ipprFilterMedianInit` function.

This function operates with VOI. This function performs median filtering on a source image with the volume. Type of the image border is defined by the value of the border parameter.

**Return Values**

- **ippStsNoErr**  Indicates no error condition. Any other value indicates an error condition.
- **ippStsStepErr**  Indicates an error condition if `srcPlaneStep`, `srcStep`, `dstPlaneStep`, or `dstStep` has a field with negative value.
- **ippStsNullPtrErr**  Indicates an error condition if the `pSrc`, `pDst`, `pSpec`, `pBorderValue`, or `pBuffer` pointer is NULL.
- **ippStsSizeErr**  Indicates an error condition if `dstRoiVolume` has a field with zero or negative value.

**See Also**

- **FilterMedianInit**  Initializes the filter specification structure for 3D image processing with a median filter.
- **FilterMedianGetSize**  Computes the size of the filter specification structure and the size of the work buffer for 3D image processing with a median filter.

**Structures and Enumerators**

**FilterMedianInit**

*Initializes the filter specification structure for 3D image processing with a median filter.*

**Syntax**

```c
IppStatus ipprFilterMedianInit(IpprVolume maskVolume, IppDataType dataType, int numChannels, IpprFilterMedianSpec* pSpec);
```

**Threading Layer (TL) function**

```c
IppStatus ipprFilterMedianInit_T(IpprVolume maskVolume, IppDataType dataType, int numChannels, IpprFilterMedianSpec_T* pSpec);
```

**Include Files**

- `ippi.h`
- `ippi_tl.h`
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

maskVolume  
Size of the mask volume.

dataType  
Data type of the source image. Possible values are ipp8u, ipp16u, ipp16s, ipp32f, and ipp64f.

numChannels  
Number of channels in the image. Possible value is 1.

pSpec  
Pointer to the filter specification structure.

Description

This function operates with VOI. This function initializes the filter specification structure pSpec for 3D image processing with a median filter. Before using this function, you need to compute the size of the corresponding specification structure using the ipprFilterMedianGetSize function.

Return Values

ippStsNoErr  
Indicates no error condition. Any other value indicates an error condition.

ippStsNullPtrErr  
Indicates an error condition if the pSpec pointer is NULL.

ippStsSizeErr  
Indicates an error condition if maskVolume has a field with zero or negative value.

ippStsChannelErr  
Indicates an error condition if numChannels has an illegal value.

ippStsDataTypeErr  
Indicates an error condition if dataType has an illegal value.

See Also

FilterMedianGetSize  Computes the size of the filter specification structure and the size of the work buffer for 3D image processing with a median filter.

FilterMedian  Filters a 3D image using a median filter.

FilterMedianGetSize

Computes the size of the filter specification structure and the size of the work buffer for 3D image processing with a median filter.

Syntax

IppStatus ipprFilterMedianGetSize(IpprVolume maskVolume, IpprVolume dstRoiVolume, IppDataType dataType, int numChannels, int* pSpecSize, int* pBufferSize);

Threading Layer (TL) function

IppStatus ipprFilterMedianGetSize_T(IpprVolume maskVolume, IpprVolume dstRoiVolume, IppDataType dataType, int numChannels, int* pSpecSize, int* pBufferSize);

Include Files

ippi.h
ippi_tl.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

maskVolume  
Size of the mask volume.

dstRoiVolume  
Maximal size of the destination image ROI (in pixels).

dataType  
Data type of the source image. Possible values are ipp8u, ipp16u, ipp16s, ipp32f, and ipp64f.

numChannels  
Number of channels in the image. Possible value is 1.

pSpecSize  
Pointer to the size of the filter specification structure.

pBufferSize  
Pointer to the size of the work buffer required for filtering.

Description

This function operates with VOI. This function computes the size of the filter specification structure pSpec and the size of the buffer required for 3D image filtering operations with a median filter. Call this function before using the ipprFilterMedianInit function.

Return Values

ippStsNoErr  
Indicates no error condition. Any other value indicates an error condition.

ippStsNullPtrErr  
Indicates an error condition if the pSpecSize or pBufferSize pointer is NULL.

ippStsSizeErr  
Indicates an error condition if dstRoiVolume or maskVolume has a field with zero or negative value.

ippStsChannelErr  
Indicates an error condition if numChannels has an illegal value.

ippStsDataTypeErr  
Indicates an error condition if dataType has an illegal value.

See Also

FilterMedianInit  Initializes the filter specification structure for 3D image processing with a median filter.

FIlterMedian  Filters a 3D image using a median filter.

ResizeGetBufSize

Calculates the size of the external work buffer for the function ipprResize.

Syntax

IppStatus ipprResizeGetBufSize(IpprCuboid srcVoi, IpprCuboid dstVoi, int nChannel, int interpolation, int* pSize);

Include Files

ippi.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

- srcVoi: Volume of interest in the source volume.
- dstVoi: Volume of interest in the destination volume.
- nChannel: Number of channels, possible value: 1.
- interpolation: Type of interpolation, the following values are possible:
  - IPPI_INTER_NN: nearest neighbor interpolation,
  - IPPI_INTER_LINEAR: trilinear interpolation,
  - IPPI_INTER_CUBIC: tricubic interpolation,
  - IPPI_INTER_CUBIC2P_BSPLINE: B-spline,
  - IPPI_INTER_CUBIC2P_CATMULLROM: Catmull-Rom spline,
  - IPPI_INTER_CUBIC2P_B05C03: special two-parameters filter (1/2, 3/10).
- pSize: Pointer to the size of the external buffer.

Description

This function calculates the size of the external buffer required for theippiResize function.

Return Values

- ippStsNoErr: Indicates no error. Any other value indicates an error.
- ippStsNullPtrErr: Indicates an error when the pSize pointer is NULL.
- ippStsSizeErr: Indicates an error when width, or height, or depth of the srcVoi or dstVoi is less than, or equal to 0.
- ippStsNumChannelErr: Indicates an error when nChannel is not equal to 1.
- ippStsInterpolationErr: Indicates an error when interpolation has an illegal value.

See Also

Resize  Resizes the source volume.

GetResizeCuboid

Computes coordinates of the destination cuboid.

Syntax

IppStatus ipprGetResizeCuboid(IpprCuboid srcVoi, IpprCuboid* pDstCuboid, double xFactor, double yFactor, double zFactor, double xShift, double yShift, double zShift, int interpolation);

Include Files

ippi.h
Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

srcVoi  
Volume of interest of the source volume.

pDstCuboid  
Pointer to the destination cuboid.

x-, y-, zFactor  
Factors by which the x, y, z dimensions of the source VOI are changed.

x-, y-, zShift  
Shift values in the x, y, and z directions respectively.

interpolation  
Type of interpolation, the following values are possible:

   IPPI_INTER_NN- nearest neighbor interpolation,
   IPPI_INTER_LINEAR- trilinear interpolation,
   IPPI_INTER_CUBIC- tricubic interpolation,
   IPPI_INTER_CUBIC2P_BSPLINE- B-spline,
   IPPI_INTER_CUBIC2P_CATMULLROM- Catmull-Rom spline,
   IPPI_INTER_CUBIC2P_B05C03- special two-parameters filter (1/2, 3/10).

Description

This function operates with volume of interest (VOI).
This function computes the coordinates of the resultant cuboid which is obtained if the source volume srcVoi
is resized with the specified parameters. The resize operation is not performed.

Return Values

ippStsNoErr  
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr  
Indicates an error when pDstCuboid is NULL.

ippStsSizeErr  
Indicates an error when width, or height, or depth of the source and destination volumes is less than, or equal to 0.

ippStsResizeFactorErr  
Indicates an error when one of the xFactor, yFactor, zFactor values is less than, or equal to 0.

ippStsInterpolationErr  
Indicates an error when interpolation has an illegal value.

Resize

Resizes the source volume.

Syntax

IppStatus ipprResize_8u_C1V(const Ipp8u* pSrc, IpprVolume srcVolume, int srcStep, int srcPlaneStep, IpprCuboid srcVoi, Ipp8u* pDst, int dstStep, int dstPlaneStep, IpprCuboid dstVoi, double xFactor, double yFactor, double zFactor, double xShift, double yShift, double zShift, int interpolation, Ipp8u* pBuffer);
IppStatus ipprResize_16u_C1V(const Ipp16u* pSrc, IpprVolume srcVolume, int srcStep, int srcPlaneStep, IpprCuboid srcVoi, Ipp16u* pDst, int dstStep, int dstPlaneStep, IpprCuboid dstVoi, double xFactor, double yFactor, double zFactor, double xShift, double yShift, double zShift, int interpolation, Ipp8u* pBuffer);

IppStatus ipprResize_8u_C1PV(const Ipp8u* const pSrc[], IpprVolume srcVolume, int srcStep, IpprCuboid srcVoi, Ipp8u* const pDst[], int dstStep, IpprCuboid dstVoi, double xFactor, double yFactor, double zFactor, double xShift, double yShift, double zShift, int interpolation, Ipp8u* pBuffer);

IppStatus ipprResize_16u_C1PV(const Ipp16u* const pSrc[], IpprVolume srcVolume, int srcStep, IpprCuboid srcVoi, Ipp16u* const pDst[], int dstStep, IpprCuboid dstVoi, double xFactor, double yFactor, double zFactor, double xShift, double yShift, double zShift, int interpolation, Ipp8u* pBuffer);

IppStatus ipprResize_32f_C1PV(const Ipp32f* const pSrc[], IpprVolume srcVolume, int srcStep, IpprCuboid srcVoi, Ipp32f* const pDst[], int dstStep, IpprCuboid dstVoi, double xFactor, double yFactor, double zFactor, double xShift, double yShift, double zShift, int interpolation, Ipp8u* pBuffer);

IppStatus ipprResize_32f_C1V(const Ipp32f* pSrc, IpprVolume srcVolume, int srcStep, int srcPlaneStep, IpprCuboid srcVoi, Ipp32f* pDst, int dstStep, int dstPlaneStep, IpprCuboid dstVoi, double xFactor, double yFactor, double zFactor, double xShift, double yShift, double zShift, int interpolation, Ipp8u* pBuffer);

### Include Files

ippi.h

### Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h

Libraries: ippcore.lib, ippvm.lib, ipps.lib

### Parameters

- **pSrc**
  - Pointer to the source volume origin. An array of pointers to the source planes for non-contiguous volume.
  - Size of the source volume.
  - Distance, in bytes, between the starting points of consecutive lines in each plane of the source volume.
  - Distance, in bytes, between the planes of the source contiguous volume.
  - Volume of interest of the source volume.

- **srcVolume**
  - Pointer to the destination volume origin. An array of pointers to the destination planes for non-contiguous volume.
  - Distance, in bytes, between the starting points of consecutive lines in each plane of the destination volume.
  - Distance, in bytes, between the planes of the destination contiguous volume.
  - Volume of interest of the destination volume.

- **srcStep**
  - Factors by which the x, y, z dimensions of the source VOI are changed.
x-, y-, zShift  

Type of interpolation, the following values are possible:

- **IPPI_INTER_NN** - nearest neighbor interpolation,
- **IPPI_INTER_LINEAR** - trilinear interpolation,
- **IPPI_INTER_CUBIC** - tricubic interpolation,
- **IPPI_INTER_CUBIC2P_BSPLINE** - B-spline,
- **IPPI_INTER_CUBIC2P_CATMULLROM** - Catmull-Rom spline,
- **IPPI_INTER_CUBIC2P_B05C03** - special two-parameters filter (1/2, 3/10).

pBuffer  

Pointer to the external buffer.

Description  

This function operates with volume of interest (VOI).

This function resizes the source volume srcVoi by xFactor in the x direction, yFactor in the y direction and zFactor in the z direction. The volume size can be reduced or increased in each direction, depending on the values of xFactor, yFactor, zFactor. If the value of the certain factor is greater than 1, the volume size is increased, and if it is less than 1, the volume size is reduced in the corresponding direction. The result is resampled using the interpolation method specified by the interpolation parameter, and written to the destination volumeVOI.

Coordinates x’, y’, and z’ in the resized volume are obtained from the equations:

\[
\begin{align*}
x' &= x \times xFactor + x\text{Shift} \\
y' &= y \times yFactor + y\text{Shift} \\
z' &= z \times z\text{Factor} + z\text{Shift}
\end{align*}
\]

where \(x\), \(y\), and \(z\) denote the coordinates of the element in the source volume. The right coordinate system (RCS) is used here.

Before using this function, compute the size of the external buffer pBuffer using ipprResizeGetBufSize.

Return Values  

- **ippStsNoErr**  
  Indicates no error. Any other value indicates an error or a warning.

- **ippStsNullPtrErr**  
  Indicates an error when one of the specified pointers is NULL.

- **ippStsSizeErr**  
  Indicates an error when width, or height, or depth of the source and destination volumes is less than or equal to 0.

- **ippStsResizeFactorErr**  
  Indicates an error when one of the xFactor, yFactor, zFactor pointers is less than, or equal to 0.

- **ippStsInterpolationErr**  
  Indicates an error when interpolation has an illegal value.

- **ippStsWrongIntersectVOI**  
  Indicates a warning when srcVoi has no intersection with the source volume, operation is not performed.

See Also  

**ResizeGetBufSize**  
Calculates the size of the external work buffer for the function ipprResize.
Remap

Performs the look-up coordinate mapping of the elements of the source volume.

Syntax

Case 1: Operation on non-contiguous volume data

IppStatus ipprRemap_8u_C1PV(const Ipp8u* pSrc[], IpprVolume srcVolume, int srcStep, IpprCuboid srcVoi, const Ipp32f* pxMap[], const Ipp32f* pyMap[], const Ipp32f* pzMap[], int mapStep, Ipp8u* pDst[], int dstStep, IpprVolume dstVolume, int interpolation);

IppStatus ipprRemap_16u_C1PV(const Ipp16u* pSrc[], IpprVolume srcVolume, int srcStep, IpprCuboid srcVoi, const Ipp32f* pxMap[], const Ipp32f* pyMap[], const Ipp32f* pzMap[], int mapStep, Ipp16u* pDst[], int dstStep, IpprVolume dstVolume, int interpolation);

IppStatus ipprRemap_32f_C1PV(const Ipp32f* pSrc[], IpprVolume srcVolume, int srcStep, IpprCuboid srcVoi, const Ipp32f* pxMap[], const Ipp32f* pyMap[], const Ipp32f* pzMap[], int mapStep, Ipp32f* pDst[], int dstStep, IpprVolume dstVolume, int interpolation);

Case 2: Operation on contiguous volume data

IppStatus ipprRemap_8u_C1V(const Ipp8u* pSrc, IpprVolume srcVolume, int srcStep, int srcPlaneStep, IpprCuboid srcVoi, const Ipp32f* pxMap, const Ipp32f* pyMap, const Ipp32f* pzMap, int mapStep, int mapPlaneStep, Ipp8u* pDst, int dstStep, int dstPlaneStep, IpprVolume dstVolume, int interpolation);

IppStatus ipprRemap_16u_C1V(const Ipp16u* pSrc, IpprVolume srcVolume, int srcStep, int srcPlaneStep, IpprCuboid srcVoi, const Ipp32f* pxMap, const Ipp32f* pyMap, const Ipp32f* pzMap, int mapStep, int mapPlaneStep, Ipp16u* pDst, int dstStep, int dstPlaneStep, IpprVolume dstVolume, int interpolation);

IppStatus ipprRemap_32f_C1V(const Ipp32f* pSrc, IpprVolume srcVolume, int srcStep, int srcPlaneStep, IpprCuboid srcVoi, const Ipp32f* pxMap, const Ipp32f* pyMap, const Ipp32f* pzMap, int mapStep, int mapPlaneStep, Ipp32f* pDst, int dstStep, int dstPlaneStep, IpprVolume dstVolume, int interpolation);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

pSrc
srcVolume
srcStep
srcPlaneStep
srcVoi

Array of pointers to the planes in the source volume.
Size of the source volume.
Distance, in bytes, between the starting points of consecutive lines in every plane of the source volume.
Distance, in bytes, between the starting points of consecutive lines in every plane of the source volume (for 8u_C1V, 16u_C1V, and 32f_C1V flavors).
Region of interest in the source volume.
Arrays of pointers to the starts of the 2D buffers, containing tables of the x-, y- and z-coordinates. If the referenced coordinates correspond to a voxel outside of the source VOI, no mapping of the source pixel is done.

Step, in bytes, through the buffers containing tables of the x-, y- and z-coordinates.

Distance, in bytes, between the starting points of consecutive lines in every plane of the buffers containing tables (for 8u_C1V, 16u_C1V, and 32f_C1V flavors).

Array of the pointers to the planes in the destination volume.

Distance, in bytes, between the starting points of consecutive lines in every plane of the destination volume.

Distance, in bytes, between the starting points of consecutive lines in every plane of the destination volume (for 8u_C1V, 16u_C1V, and 32f_C1V flavors).

Size of the destination volume.

The type of interpolation, the following values are possible:

- IPPI_INTER_NN- nearest neighbor interpolation,
- IPPI_INTER_LINEAR- trilinear interpolation,
- IPPI_INTER_CUBIC- tricubic interpolation,
- IPPI_INTER_CUBIC2P_BSPLINE- B-spline,
- IPPI_INTER_CUBIC2P_CATMULLROM- Catmull-Rom spline,
- IPPI_INTER_CUBIC2P_B05C03- special two-parameters filter (1/2, 3/10).

**Description**

This function operates with volume of interest (VOI).

This function transforms the source volume by remapping its voxels. Voxel remapping is performed using pxMap, pyMap and pzMap buffers to look-up the coordinates of the source volume voxel that is written to the target destination volume voxel. The application has to supply these look-up tables.

The remapping of the source voxels to the destination voxels is made according to the following formulas:

\[
dst\_voxel[i, j, k] = src\_voxel[pxMap[i, j, k], pyMap[i, j, k], pzMap[i, j, k]]
\]

where \(i, j, k\) are the x-, y- and z-coordinates of the target destination volume voxel \(dst\_voxel\);

\(pxMap[i, j, k]\) contains the x-coordinates of the source volume voxels \(src\_voxel\) that are written to \(dst\_voxel\).

\(pyMap[i, j, k]\) contains the y-coordinates of the source volume voxels \(src\_voxel\) that are written to \(dst\_voxel\).

\(pzMap[i, j, k]\) contains the z-coordinates of the source volume voxels \(src\_voxel\) that are written to \(dst\_voxel\).

**Return Values**

- ippStsNoErr: Indicates no error. Any other value indicates an error or a warning.
- ippStsNullPtrErr: Indicates an error when one of the specified pointers is NULL.
WarpAffineGetBufSize

Calculates the size of the external buffer for the affine transform.

Syntax

IppStatus ipprWarpAffineGetBufSize(IpprVolume srcVolume, IpprCuboid srcVoi, IpprCuboid dstVoi, const double coeffs[3][4], int nChannel, int interpolation, int* pSize);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib

Parameters

**srcVolume**
Size of the source volume.

**srcVoi**
Region of interest of the source volume.

**dstVoi**
Region of interest of the destination volume.

**coeffs**
Affine transform matrix.

**nChannel**
Number of channel or planes, possible value is 1.

**interpolation**
Type of interpolation, the following values are possible:

- IPPI_INTER_NN  - nearest neighbor interpolation,
- IPPI_INTER_LINEAR - trilinear interpolation,
- IPPI_INTER_CUBIC - tricubic interpolation,
- IPPI_INTER_CUBIC2P_BSPLINE - B-spline,
- IPPI_INTER_CUBIC2P_CATMULLROM - Catmull-Rom spline,
- IPPI_INTER_CUBIC2P_B05C03 - special two-parameters filter (1/2, 3/10).

**pSize**
Pointer to the size of the external buffer.

Description

This function calculates the size (in bytes) of the external buffer that is required for the ipprWarpAffine function. (In some cases the function returns zero size of the buffer).
Return Values

ippStsNoErr Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr Indicates an error when pSize or coeffs is NULL.

ippStsSizeErr Indicates an error if width, or height, or depth of the srcVoi or dstVoi is less than, or equal to zero.

ippStsNumChannelErr Indicates an error when nChannel has an illegal value.

ippStsInterpolationErr Indicates an error when interpolation has an illegal value.

See Also

WarpAffine Performs the general affine transform of the source volume.

WarpAffine

Performs the general affine transform of the source volume.

Syntax

IppStatus ipprWarpAffine_8u_C1PV(const Ipp8u* const pSrc[], IpprVolume srcVolume, int srcStep, IpprCuboid srcVoi, Ipp8u* const pDst[], int dstStep, IpprCuboid dstVoi, const double coeffs[3][4], int interpolation, Ipp8u* pBuffer);

IppStatus ipprWarpAffine_16u_C1PV(const Ipp16u* const pSrc[], IpprVolume srcVolume, int srcStep, IpprCuboid srcVoi, Ipp16u* const pDst[], int dstStep, IpprCuboid dstVoi, const double coeffs[3][4], int interpolation, Ipp8u* pBuffer);

IppStatus ipprWarpAffine_32f_C1PV(const Ipp32f* const pSrc[], IpprVolume srcVolume, int srcStep, IpprCuboid srcVoi, Ipp32f* const pDst[], int dstStep, IpprCuboid dstVoi, const double coeffs[3][4], int interpolation, Ipp8u* pBuffer);

IppStatus ipprWarpAffine_8u_C1V(const Ipp8u* pSrc, IpprVolume srcVolume, int srcStep, int srcPlaneStep, IpprCuboid srcVoi, Ipp8u* pDst, int dstStep, int dstPlaneStep, IpprCuboid dstVoi, const double coeffs[3][4], int interpolation, Ipp8u* pBuffer);

IppStatus ipprWarpAffine_16u_C1V(const Ipp16u* pSrc, IpprVolume srcVolume, int srcStep, int srcPlaneStep, IpprCuboid srcVoi, Ipp16u* pDst, int dstStep, int dstPlaneStep, IpprCuboid dstVoi, const double coeffs[3][4], int interpolation, Ipp8u* pBuffer);

IppStatus ipprWarpAffine_32f_C1V(const Ipp32f* pSrc, IpprVolume srcVolume, int srcStep, int srcPlaneStep, IpprCuboid srcVoi, Ipp32f* pDst, int dstStep, int dstPlaneStep, IpprCuboid dstVoi, const double coeffs[3][4], int interpolation, Ipp8u* pBuffer);

Include Files

ippi.h

Domain Dependencies

Headers: ippcore.h, ippvm.h, ipps.h
Libraries: ippcore.lib, ippvm.lib, ipps.lib
Parameters

**pSrc**
Array of pointers to the planes in the source volume.

**srcVolume**
Size, in pixels, of the source volume.

**srcStep**
Distance, in bytes, between the starting points of consecutive lines in each plane of the source volume.

**srcPlaneStep**
Distance, in bytes, between the starting points of consecutive lines in every plane of the source volume (for 8u_C1V, 16u_C1V, and 32f_C1V flavors).

**dstStep**
Distance, in bytes, between the starting points of consecutive lines in each plane of the destination volume.

**srcVoi**
Volume of interest of the source volume.

**pDst**
Array of pointers to the planes in the destination volume.

**dstVoi**
Volume of interest of the destination volume.

**dstStep**
Distance, in bytes, between the starting points of consecutive lines in every plane of the destination volume.

**dstPlaneStep**
Distance, in bytes, between the starting points of consecutive lines in every plane of the destination volume (for 8u_C1V, 16u_C1V, and 32f_C1V flavors).

**coeffs**
Coefficients of the affine transform.

**interpolation**
Type of interpolation, the following values are possible:
- IPPI_INTER_NN - nearest neighbor interpolation,
- IPPI_INTER_LINEAR - trilinear interpolation,
- IPPI_INTER_CUBIC - tricubic interpolation,
- IPPI_INTER_CUBIC2P_BSPLINE - B-spline,
- IPPI_INTER_CUBIC2P_CATMULLROM - Catmull-Rom spline,
- IPPI_INTER_CUBIC2P_B05C03 - special two-parameters filter (1/2, 3/10).

**pBuffer**
Pointer to the external buffer.

Description

This function operates with volume of interest (VOI).

This affine warp function transforms the coordinates \((x, y, z)\) of the source volume voxels according to the following formulas:

\[
\begin{align*}
x' &= c_{00}x + c_{01}y + c_{02}z + c_{03} \\
y' &= c_{10}x + c_{11}y + c_{12}z + c_{13} \\
z' &= c_{20}x + c_{21}y + c_{22}z + c_{23}
\end{align*}
\]

where \(x', y'\) and \(z'\) denote the voxel coordinates in the transformed volume, and \(c_{ij}\) are the affine transform coefficients stored in the array \(\text{coeffs}\).

Before calling this function, compute the size of the external buffer \(\text{pBuffer}\) using the \(\text{ipprWarpAffineGetBufSize}\) function.
Return Values

ippStsNoErr
Indicates no error. Any other value indicates an error or a warning.

ippStsNullPtrErr
Indicates an error when one of the specified pointers is NULL.

ippStsSizeErr
Indicates an error when width, or height, or depth of the source and destination volumes is less than, or equal to zero.

ippStsCoeffErr
Indicates an error when determinant of the transform matrix \( c_{ij} \) is equal to zero.

ippStsInterpolationErr
Indicates an error when interpolation has an illegal value.

ippStsWrongIntersectVOI
Indicates a warning when srcVoi has no intersection with the source volume, operation is not performed.

See Also
WarpAffineGetBufSize  Calculates the size of the external buffer for the affine transform.
Handling of Special Cases

Some mathematical functions implemented in Intel IPP are not defined for all possible argument values. This appendix describes how the corresponding Intel IPP image processing functions handle situations when their input arguments fall outside the range of function definition or may lead to ambiguously determined output results.

Table A-1 below summarizes these special cases for different functions and lists result values together with status codes returned by the functions. The status codes ending with \texttt{Err} (except for the \texttt{ippStsNoErr} status) indicate an error. When an error occurs, the function execution is interrupted. All other status codes indicate that the input argument is outside the range, but the function execution is continued with the corresponding result value.

**Special Cases for Intel IPP Image Processing Functions**

<table>
<thead>
<tr>
<th>Function Base Name</th>
<th>Data Type</th>
<th>Case Description</th>
<th>Result Value</th>
<th>Status Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>ippiSqrt</td>
<td>16s</td>
<td>Sqrt (x &lt;0)</td>
<td>0</td>
<td>ippStsSqrtNegArg</td>
</tr>
<tr>
<td></td>
<td>32f</td>
<td>Sqrt (x &lt;0)</td>
<td>NAN_32F</td>
<td>ippStsSqrtNegArg</td>
</tr>
<tr>
<td>ippiDiv</td>
<td>8u</td>
<td>Div (0/0)</td>
<td>0</td>
<td>ippStsDivByZero</td>
</tr>
<tr>
<td></td>
<td>16s</td>
<td>Div (0/0), x&gt;0</td>
<td>IPP_MAX_16S</td>
<td>ippStsDivByZero</td>
</tr>
<tr>
<td></td>
<td>16s</td>
<td>Div (x/0), x&lt;0</td>
<td>IPP_MIN_16S</td>
<td>ippStsDivByZero</td>
</tr>
<tr>
<td></td>
<td>32f</td>
<td>Div (x/0), x&gt;0</td>
<td>INF_32F</td>
<td>ippStsDivByZero</td>
</tr>
<tr>
<td></td>
<td>32f</td>
<td>Div (x/0), x&lt;0</td>
<td>INF_NEG_32F</td>
<td>ippStsDivByZero</td>
</tr>
<tr>
<td></td>
<td>16sc</td>
<td>Div (0/0)</td>
<td>0</td>
<td>ippStsDivByZero</td>
</tr>
<tr>
<td></td>
<td>16sc</td>
<td>Div (x/0)</td>
<td>0</td>
<td>ippStsDivByZero</td>
</tr>
<tr>
<td></td>
<td>32sc</td>
<td>Div (x/0)</td>
<td>0</td>
<td>ippStsDivByZero</td>
</tr>
<tr>
<td></td>
<td>32sc</td>
<td>Div (x/0), x&gt;0</td>
<td>IPP_MAX_32S</td>
<td>ippStsDivByZero</td>
</tr>
<tr>
<td></td>
<td>32sc</td>
<td>Div (x/0), x&lt;0</td>
<td>IPP_MIN_32S</td>
<td>ippStsDivByZero</td>
</tr>
<tr>
<td></td>
<td>32fc</td>
<td>Div (x/0)</td>
<td>NAN_32F</td>
<td>ippStsDivByZero</td>
</tr>
<tr>
<td></td>
<td>32fc</td>
<td>Div (x/0), x&gt;0</td>
<td>INF_32F</td>
<td>ippStsDivByZero</td>
</tr>
<tr>
<td></td>
<td>32fc</td>
<td>Div (x/0), x&lt;0</td>
<td>INF_NEG_32F</td>
<td>ippStsDivByZero</td>
</tr>
<tr>
<td>ippiDivC</td>
<td>all</td>
<td>Div(x/const),</td>
<td>-</td>
<td>ippStsDivByZeroErr</td>
</tr>
<tr>
<td></td>
<td></td>
<td>const=0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function Base Name</td>
<td>Data Type</td>
<td>Case Description</td>
<td>Result Value</td>
<td>Status Code</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------</td>
<td>------------------</td>
<td>--------------</td>
<td>------------------</td>
</tr>
<tr>
<td>ippiLn</td>
<td>8u</td>
<td>Ln (0)</td>
<td>0</td>
<td>ippStsLnZeroArg</td>
</tr>
<tr>
<td></td>
<td>16s</td>
<td>Ln (0)</td>
<td>IPP_MIN_16S</td>
<td>ippStsLnZeroArg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ln (&lt;0)</td>
<td>IPP_MIN_16S</td>
<td>ippStsLnNegArg</td>
</tr>
<tr>
<td></td>
<td>32f</td>
<td>Ln (&lt;0)</td>
<td>NAN_32F</td>
<td>ippStsLnNegArg</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ln(x&lt;IPP_MINABS_32F)</td>
<td>INF_NEG_32F</td>
<td>ippStsLnZeroArg</td>
</tr>
<tr>
<td>ippiExp</td>
<td>8u</td>
<td>overflow</td>
<td>IPP_MAX_8U</td>
<td>ippStsNoErr</td>
</tr>
<tr>
<td></td>
<td>16s</td>
<td>overflow</td>
<td>IPP_MAX_16S</td>
<td>ippStsNoErr</td>
</tr>
<tr>
<td></td>
<td>32f</td>
<td>overflow</td>
<td>INF_32F</td>
<td>ippStsNoErr</td>
</tr>
</tbody>
</table>

Here \(x\) denotes an input value. For the definition of the constants used, see Image Data Types and Ranges in chapter 2.

Note that flavors of the same math function operating on different data types may produce different results for the equal argument values. However, for a given function and a fixed data type, handling of special cases is the same for all function flavors that have different descriptors in their names. For example, logarithm function \(ippiLn\) operating on 16s data treats zero argument values in the same way for all its flavors \(ippiLn_{16s\_C1RSfs}, ippiLn_{16s\_C3RSfs}, ippiLn_{16s\_C1IRSfs}, \) and \(ippiLn_{16s\_C3IRSfs}\.\)
Interpolation in Image Geometric Transform Functions

This appendix describes the interpolation algorithms used in the geometric transformation functions of Intel IPP. For more information about each of the geometric transform functions, see Chapter 12.

Overview of Interpolation Modes

In geometric transformations, the grid of input image pixels is not necessarily mapped onto the grid of pixels in the output image. Therefore, to compute the pixel intensities in the output image, the geometric transform functions need to interpolate the intensity values of several input pixels that are mapped to a certain neighborhood of the output pixel.

Geometric transformations can use various interpolation algorithms. The library supports the following interpolation modes depending on how the type of interpolation algorithm is specified:

- **Type 1:** Application code specifies the interpolation mode by passing the `interpolation` parameter of `int` type to a processing function. The following interpolation modes are supported:
  - Nearest neighbor interpolation (`interpolation = IPPI_INTER_NN`)
  - Linear interpolation (`interpolation = IPPI_INTER_LINEAR`)
  - Cubic interpolation (`interpolation = IPPI_INTER_CUBIC`)
  - Interpolation with Lanczos window function (`interpolation = IPPI_INTER_LANCZOS`)
  - Interpolation with two-parameter cubic filters with the fixed coefficients (`interpolation` can be set to the following):
    - `IPPI_INTER_CUBIC2P_BSPLINE (B=1; C=0)`
    - `IPPI_INTER_CUBIC2P_CATMULLROM (B=0; C=0.5)`
    - `IPPI_INTER_CUBIC2P_B05C03 (B=0.5; C=0.3)`

- **Type 2:** Interpolation mode is specified explicitly in a function name suffix:
  - Nearest neighbor interpolation (pass `interpolation = ippNearest` to `GetSize` functions, use the functions with the `Nearest` suffix, for example, `ResizeNearestInit` or `ResizeNearest`)
  - Linear interpolation (pass `interpolation = ippLinear` to `GetSize` functions, use the functions with the `Linear` suffix, for example, `ResizeLinearInit` or `ResizeLinear`)
  - Interpolation with two-parameter cubic filters (pass `interpolation = ippCubic` to `GetSize` functions, use the functions with the `Cubic` suffix, for example, `ResizeCubicInit` or `ResizeCubic`)
  - Supersampling (pass `interpolation = ippSuper` to `GetSize` functions, use the functions with the `Super` suffix, for example, `ResizeSuperInit` or `ResizeSuper`)
  - Interpolation with Lanczos window function (pass `interpolation = ippLanczos` to `GetSize` functions, use the functions with the `Lanczos` suffix, for example, `ResizeLanczosInit` or `ResizeLanczos`)

For certain functions of type 1, the specified interpolation modes can be combined with additional *smoothing of edges* to which the borders of the original image are transformed. To use this option, for the `interpolation` parameter, specify the edge smoothing flag and the desired interpolation mode using the bitwise OR operation. For example, in order to rotate an image with cubic interpolation and smooth the rotated image edges, pass the following value to `ippiRotate()`:

`interpolation = IPPI_INTER_CUBIC | IPPI_SMOOTH_EDGE`.

To enable edge smoothing for functions of type 2, pass the special flag to the `Init` function (if it exists), for example, you can pass this flag to `Init` functions for `WarpAffine` and `WarpPerspective` function groups.

Interpolation with edge smoothing option can be used only in those geometric transform functions where this option is explicitly listed in the parameters definition section.
Table B-1 lists the supported interpolation modes for the main geometric transform functions that use interpolation.

### Interpolation Modes Supported by Image Geometric Transform Functions

<table>
<thead>
<tr>
<th>Function Base Name</th>
<th>NN</th>
<th>Lin</th>
<th>Cub2P</th>
<th>Cub</th>
<th>CR</th>
<th>La2</th>
<th>La3</th>
<th>SS</th>
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*) The function `ippiResizeCubic` supports the interpolation with two-parameter cubic filters, where parameters B and C can be specified explicitly.

Here **NN** - nearest neighbor interpolation, **Lin** - linear interpolation, **Cub2P** - interpolation with two-parameter cubic filters, **Cub** - cubic interpolation, **CR** - Catmull-Rom spline, **La2, La3** - interpolation with the Lanczos window, **SS** - super sampling interpolation, **AA** - antialiasing, **ES** - edge smoothing.

The sections that follow provide more details on each interpolation mode.

### Mathematical Notation

In this appendix the following notation is used:

- \((x_D, y_D)\) pixel coordinates in the destination image (integer values);
- \((x_S, y_S)\) the computed coordinates of a point in the source image that is mapped exactly to \((x_D, y_D)\);
- \(S(x, y)\) pixel value (intensity) in the source image;
- \(D(x, y)\) pixel value (intensity) in the destination image.

### Nearest Neighbor Interpolation

This is the fastest and least accurate interpolation mode. The pixel value in the destination image is set to the value of the source image pixel closest to the point

\((x_S, y_S): D(x_D, y_D) = S(\text{round}(x_S), \text{round}(y_S)).\)

To use the nearest neighbor interpolation, set the **interpolation** parameter to `IPPI_INTER_NN` or use the functions with the **Nearest** suffix (pass `interpolation=ippNearest` to `GetSize` functions).
Linear Interpolation

The linear interpolation is slower but more accurate than the nearest neighbor interpolation. On the other hand, it is faster but less accurate than cubic interpolation. The linear interpolation algorithm uses source image intensities at the four pixels \((x_{S0}, y_{S0}), (x_{S1}, y_{S0}), (x_{S0}, y_{S1}), (x_{S1}, y_{S1})\) that are closest to \((x_S, y_S)\) in the source image:

\[
x_{S0} = \text{int}(x_S), \ x_{S1} = x_{S0} + 1, \ y_{S0} = \text{int}(y_S), \ y_{S1} = y_{S0} + 1.
\]

First, the intensity values are interpolated along the x-axis to produce two intermediate results \(I_0\) and \(I_1\) (see Figure B-1):

\[
I_0 = S(x_S, y_{S0}) = S(x_{S0}, y_{S0})*(x_{S1} - x_S) + S(x_{S1}, y_{S0})*(x_S - x_{S0})
\]
\[
I_1 = S(x_S, y_{S1}) = S(x_{S0}, y_{S1})*(x_{S1} - x_S) + S(x_{S1}, y_{S1})*(x_S - x_{S0}).
\]

Then, the sought-for intensity \(D(x_D, y_D)\) is computed by interpolating the intermediate values \(I_0\) and \(I_1\) along the y-axis:

\[
D(x_D, y_D) = I_0*(y_{S1} - y_S) + I_1*(y_S - y_{S0}).
\]

To use the linear interpolation, set the interpolation parameter to IPPI_INTER_LINEAR or use the functions with the Linear suffix (pass interpolation=ippLinear to GetSize functions). For images with 8-bit unsigned color channels, theippiWarpAffine andippiResizeLinear functions compute the coordinates \((x_S, y_S)\) with the accuracy \(2^{-16} = 1/65536\). For images with 16-bit unsigned color channels, these functions compute the coordinates with floating-point precision.

Cubic Interpolation

The cubic interpolation algorithm (see Figure B-2) uses source image intensities at sixteen pixels in the neighborhood of the point \((x_S, y_S)\) in the source image:

\[
x_{S0} = \text{int}(x_S) - 1; \ x_{S1} = x_{S0} + 1; \ x_{S2} = x_{S0} + 2; \ x_{S3} = x_{S0} + 3;
\]
\[
y_{S0} = \text{int}(y_S) - 1; \ y_{S1} = y_{S0} + 1; \ y_{S2} = y_{S0} + 2; \ y_{S3} = y_{S0} + 3.
\]

First, for each \(y_{Sk}\) the algorithm determines four cubic polynomials \(F_0(x), F_1(x), F_2(x), \text{ and } F_3(x)\):

\[
F_k(x) = a_kx^3 + b_kx^2 + c_kx + d_k, \ 0 \leq k \leq 3
\]
such that
\[ F_k(x_{S0}) = S(x_{S0}, y_{Sk}); \quad F_k(x_{S1}) = S(x_{S1}, y_{Sk}), \]
\[ F_k(x_{S2}) = S(x_{S2}, y_{Sk}); \quad F_k(x_{S3}) = S(x_{S3}, y_{Sk}). \]
In Figure B-2, these polynomials are shown by solid curves.

Then, the algorithm determines a cubic polynomial \( F_y(y) \) such that
\[ F_y(y_{S0}) = F_0(x_S), \quad F_y(y_{S1}) = F_1(x_S), \quad F_y(y_{S2}) = F_2(x_S), \quad F_y(y_{S3}) = F_3(x_S). \]
The polynomial \( F_y(y) \) is represented by the dashed curve in Figure B-2.
Finally, the sought intensity \( D(x_D, y_D) \) is set to the value \( F_y(y_S) \).
To use the cubic interpolation, set the \textit{interpolation} parameter to \texttt{IPPI\_INTER\_CUBIC}.

\section*{Cubic Interpolation}

\[ \text{Intensity} \]

\section*{Super Sampling}

If the destination image is much smaller than the source image, the above interpolation algorithms may skip some pixels in the source image (that is, these algorithms not necessarily use all source pixels when computing intensity of the destination pixels).

The super-sampling algorithm is as follows:

1. Divide the source image rectangular ROI (or the whole image, if there is no ROI) into equal rectangles, each rectangle corresponding to some pixel in the destination image. Note that each source pixel is represented by a 1x1 square.
2. Compute a weighted sum of source pixel values for all pixels that are in the rectangle or have a non-zero intersection with the rectangle. If a source pixel is fully contained in the rectangle, the value of that pixel is taken with weight 1. If the rectangle and the square of the source pixel have an intersection of area \( a < 1 \), that pixel's value is taken with weight \( a \).

Figure B-3 shows the corresponding weight value for each source pixel intersecting with the rectangle.
3. To compute the pixel value in the destination image, divide this weighted sum by the ratio of the source and destination rectangle areas \( S_{Src} / S_{Dst} = 1/xFactor \times yFactor \).

Here \( xFactor \), and \( yFactor \) are the parameters of the functions that specify the factors by which the \( x \) and \( y \) dimensions of the source image ROI are changed.

Note that supersampling interpolation can be used only for \( xFactor<1 \), and \( yFactor<1 \).
To use the supersampling interpolation, use the functions with the Super suffix (pass interpolation=ippSuper to GetSize functions).

**Supersampling Weights**

![Supersampling Weights Diagram]

**Lanczos Interpolation**

This method is based on the 2-lobed or 3-lobed Lanczos window function as the interpolation function.

**Interpolation with the 2-lobed Lanczos Window Function**

The interpolation algorithm uses source image intensities at 16 pixels in the neighborhood of the point \((x_S, y_S)\) in the source image:

\[
x_{S0} = \text{int}(x_S) - 1; \quad x_{S1} = x_{S0} + 1; \quad x_{S2} = x_{S0} + 2; \quad x_{S3} = x_{S0} + 3;
\]

\[
y_{S0} = \text{int}(y_S) - 1; \quad y_{S1} = y_{S0} + 1; \quad y_{S2} = y_{S0} + 2; \quad y_{S3} = y_{S0} + 3;
\]

First, the intensity values are interpolated along the x-axis to produce four intermediate results \(I_0, I_1, I_2, I_3\):

\[
I_k = \sum_{i=0}^{3} a_i \cdot g(x_{Si}, y_{Sk}), \quad 0 \leq k \leq 3
\]

Then the intensity \(D(x_D, y_D)\) is computed by interpolating the intermediate values \(I_k\) along the y-axis:

\[
D(x_D, y_D) = \sum_{k=0}^{3} b_k \cdot I_k
\]

Here \(a_i\) and \(b_k\) are the coefficients defined as

\[
a_i = L(x_S-x_{Si}), \quad b_k = L(y_S-y_{Si}),
\]

where \(L(x)\) is the Lanczos windowed sinc function:

\[
L(x) = \sin c(x) \cdot \text{Lanczos2}(x) = \begin{cases} \frac{\sin(\pi x)}{\pi x}, & 0 \leq |x| < 2 \\ \frac{\sin((\pi x)/2)}{(\pi x)/2}, & 2 \leq |x| \end{cases}
\]

To use this interpolation, use the ippiResizeLanczos function.
Interpolation with the 3-lobed Lanczos Window Function

The interpolation algorithm uses source image intensities at 36 pixels in the neighborhood of the point \((x_S, y_S)\) in the source image:

\[
x_{S0} = \text{int}(x_S) - 2; \quad x_{S1} = x_{S0} + 1; \quad x_{S2} = x_{S0} + 2; \quad x_{S3} = x_{S0} + 3; \quad x_{S4} = x_{S0} + 4; \quad x_{S5} = x_{S0} + 5;
\]
\[
y_{S0} = \text{int}(y_S) - 2; \quad y_{S1} = y_{S0} + 1; \quad y_{S2} = y_{S0} + 2; \quad y_{S3} = y_{S0} + 3; \quad y_{S4} = y_{S0} + 4; \quad y_{S5} = y_{S0} + 5;
\]

First, the intensity values are interpolated along the \(x\)-axis to produce six intermediate results \(I_0, I_1, \ldots, I_5\):

\[
I_k = \sum_{i=0}^{5} a_i \cdot s(x_{Si}, y_{Si}), \quad 0 \leq k \leq 5
\]

Then the intensity \(D(x_D, y_D)\) is computed by interpolating the intermediate values \(I_k\) along the \(y\)-axis:

\[
D(x_D, y_D) = \sum_{k=0}^{5} b_k \cdot I_k
\]

Here, \(a_i\) and \(b_k\) are the coefficients defined as
\[
a_i = L(x_{Si} - x_S), \quad b_k = L(y_{Si} - y_S),
\]

where \(L(x)\) is the Lanczos windowed sinc function:

\[
L(x) = \sin c(x) \cdot \text{Lanczos3}(x) = \begin{cases} \sin(\pi x) \cdot \sin((\pi x)/3), & 0 \leq |x| < \pi/2 \\ (\pi x)/3, & \pi/2 \leq |x| < 3 \pi/2 \\ 0, & |x| \geq 3 \pi/2 \end{cases}
\]

To use this interpolation, set the interpolation parameter to `IPPI_INTER_LANCZOS`, or use the functions with the `Lanczos` suffix (pass `interpolation=ippLanczos` to `GetSize` functions).

Interpolation with Two-Parameter Cubic Filters

The two-parameter family of cubic filters have kernels of the form:

\[
k(x) = \begin{cases} (12 - 9B - 6C)|x|^3 + (-18 + 12B + 6C)|x|^2 + (6 - 2B), & |x| < 1 \\ (B - 6C)|x|^3 + (6B + 30C)|x|^2 + (-12B - 48C)|x| + (8B + 24C), & 1 \leq |x| < 2 \\ 0, & \text{otherwise} \end{cases}
\]

where \(B\) and \(C\) are two parameters; their variations give different approximation.

These interpolation methods additionally filter the output to improve quality of an image.

To get more information about how \(B\) and \(C\) values affect the result, refer to [Mitchell88].

To use the interpolation with two-parameter cubic filters, use the functions with the `Cubic` suffix (pass `interpolation=ippCubic` to `GetSize` functions).
# Appendix C: Removed Functions for Image and Video Processing

This appendix contains tables that list the functions removed from Intel IPP 9.0. If an application created with the previous versions calls a function listed here, then the source code must be modified. The tables specify the corresponding Intel IPP 9.0 functions or workaround to replace the removed functions:

- `ippcc.h`
- `ippcv.h`
- `ippi.h`
- `ippj.h` - the whole domain is removed
- `ippvc.h` - the whole domain is removed

**NOTE**

To get information on possible alternatives to the removed functions that do not have substitution or workaround in Intel IPP 2019, refer to https://software.intel.com/en-us/articles/the-alternatives-for-intel-ipp-legacy-domains-and-functions or file a support request at Online Service Center.

### ippcc.h

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### Appendix C: Removed Functions for Image and Video Processing

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## Appendix C: Removed Functions for Image and Video Processing

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## Appendix C: Removed Functions for Image and Video Processing

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### Appendix C: Removed Functions for Image and Video Processing

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**Intel® Integrated Performance Primitives Developer Reference, Volume 2: Image Processing**
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<td>ippiFFTInitAlloc_R_32f</td>
<td>ippiFFTGetSize+ippiMalloc+ippiFFTInit</td>
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<tr>
<td>ippiFFTInitAlloc_R_32s</td>
<td>ippiConvert_32s32f(or to 64f)+ippiFFTGetSize+ippiMalloc+ippiFFTInit</td>
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<td>ippiFFTInv_PackToR_32s8u_AC4RSfs</td>
<td>ippiFFTFwd_PackToR_32f+ippiConvert_32f8u</td>
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<tr>
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<td>ippiFFTFwd_PackToR_32f+ippiConvert_32f8u</td>
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<td>ippiFFTFwd_PackToR_32f+ippiConvert_32f8u</td>
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<tr>
<td>ippiFilter32f_16s_AC4R</td>
<td>ippiFilterBorderInit_32f+ippiFilterBorder_16s_C4R</td>
</tr>
<tr>
<td>ippiFilter32f_16s_C1R</td>
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### NOTE
Starting from Intel IPP 9.0, kernel coefficients in the ippiFilterBorder functions are used in direct order, as opposed to the inverse order used in lower versions. Make sure to change the filter order when replacing removed functions with ippiFilterBorder.
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<tr>
<td>ippiFilter32f_16u_AC4R</td>
<td><strong>NOTE</strong> Starting from Intel IPP 9.0, kernel coefficients in the ippiFilterBorder functions are used in direct order, as opposed to the inverse order used in lower versions. Make sure to change the filter order when replacing removed functions with ippiFilterBorder. ippiFilterBorderInit_32f +ippiFilterBorder_16u_C4R</td>
</tr>
<tr>
<td>ippiFilter32f_16u_C1R</td>
<td><strong>NOTE</strong> Starting from Intel IPP 9.0, kernel coefficients in the ippiFilterBorder functions are used in direct order, as opposed to the inverse order used in lower versions. Make sure to change the filter order when replacing removed functions with ippiFilterBorder. ippiFilterBorderInit_32f +ippiFilterBorder_16u_C1R</td>
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| `ippiFilter32f_32s_C1R` | `ippiFilterBorderInit_32f`  
`ippiConvert_32s32f`  
`ippiFilterBorder_32f_C1R` |
| `ippiFilter32f_32s_C3R` | `ippiFilterBorderInit_32f`  
`ippiConvert_32s32f`  
`ippiFilterBorder_32f_C3R` |
| `ippiFilter32f_32s_C4R` | `ippiFilterBorderInit_32f`  
`ippiConvert_32s32f`  
`ippiFilterBorder_32f_C4R` |
| `ippiFilter32f_8s16s_C1R` | `ippiFilterBorderInit_32f`  
`ippiConvert_8s16s`  
`ippiFilterBorder_16s_C1R` |
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<tr>
<td>ippiFilter32f_8s16s_C3R</td>
<td>ippiFilterBorderInit_32f +ippiConvert_8s16s +ippiFilterBorder_16s_C3R</td>
</tr>
<tr>
<td>ippiFilter32f_8s16s_C4R</td>
<td>ippiFilterBorderInit_32f +ippiConvert_8s16s +ippiFilterBorder_16s_C4R</td>
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<tr>
<td>ippiFilter32f_8s_C1R</td>
<td>ippiFilterBorderInit_32f +ippiConvert_8s16s +ippiFilterBorder_16s_C1R</td>
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<tr>
<td>ippiFilter32f_8s_C3R</td>
<td>ippiFilterBorderInit_32f +ippiConvert_8s16s +ippiFilterBorder_16s_C3R</td>
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**NOTE** Starting from Intel IPP 9.0, kernel coefficients in the `ippiFilterBorder` functions are used in direct order, as opposed to the inverse order used in lower versions. Make sure to change the filter order when replacing removed functions with `ippiFilterBorder`. 

```c
ippiFilter32f_8s16s_C3R
+ippiConvert_8s16s
+ippiFilterBorder_16s_C3R
```
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| `ippiFilter32f_8s_C4R` | `ippiFilterBorderInit_32f`  
+`ippiConvert_8s16s`  
+`ippiFilterBorder_16s_C4R` |
|                  | **NOTE** Starting from Intel IPP 9.0, kernel coefficients in the `ippiFilterBorder` functions are used in direct order, as opposed to the inverse order used in lower versions. Make sure to change the filter order when replacing removed functions with `ippiFilterBorder`. |
| `ippiFilter32f_8u16s_C1R` | `ippiFilterBorderInit_32f`  
+`ippiConvert_8u16s`  
+`ippiFilterBorder_16s_C1R` |
|                  | **NOTE** Starting from Intel IPP 9.0, kernel coefficients in the `ippiFilterBorder` functions are used in direct order, as opposed to the inverse order used in lower versions. Make sure to change the filter order when replacing removed functions with `ippiFilterBorder`. |
| `ippiFilter32f_8u16s_C3R` | `ippiFilterBorderInit_32f`  
+`ippiConvert_8u16s`  
+`ippiFilterBorder_16s_C3R` |
|                  | **NOTE** Starting from Intel IPP 9.0, kernel coefficients in the `ippiFilterBorder` functions are used in direct order, as opposed to the inverse order used in lower versions. Make sure to change the filter order when replacing removed functions with `ippiFilterBorder`. |
| `ippiFilter32f_8u16s_C4R` | `ippiFilterBorderInit_32f`  
+`ippiConvert_8u16s`  
+`ippiFilterBorder_16s_C4R` |
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<td>ippiFilterBorderInit_32f +ippiFilterBorder_8u_C4R</td>
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<td>ippFilterBilateralBorderInit</td>
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<td>ippFilterBilateralBorder_8u_C1R</td>
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<td>Use ippFilterBoxBorder</td>
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## Appendix C: Removed Functions for Image and Video Processing

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<td>ippifilterBorderInit_32f + ippifilterBorder_16s_C4R (with filter.width=1)</td>
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- ippiFilterColumn_8u_C4R
- ippiFilterGauss_16s_AC4R
- ippiFilterGauss_16s_C1R
- ippiFilterGauss_16s_C3R
- ippiFilterGauss_16s_C4R
- ippiFilterGauss_16u_AC4R
- ippiFilterGauss_16u_C1R
- ippiFilterGauss_16u_C3R
- ippiFilterGauss_16u_C4R
- ippiFilterGauss_32f_AC4R
- ippiFilterGauss_32f_C1R
- ippiFilterGauss_32f_C3R
- ippiFilterGauss_32f_C4R
- ippiFilterGauss_8u_AC4R
- ippiFilterGauss_8u_C1R

### Substitution or Workaround

**NOTE** Starting from Intel IPP 9.0, kernel coefficients in the `ippiFilterBorder` functions are used in direct order, as opposed to the inverse order used in lower versions. Make sure to change the filter order when replacing removed functions with `ippiFilterBorder`.

- `ippiFilterBorderInit_16s`
- `ippiFilterBorder_8u_C4R (with filter.width=1)`

**NOTE** Starting from Intel IPP 9.0, kernel coefficients in the `ippiFilterBorder` functions are used in direct order, as opposed to the inverse order used in lower versions. Make sure to change the filter order when replacing removed functions with `ippiFilterBorder`.

- `ippiCopy_C4C1R`
- `ippiFilterGaussianBorder_16s_C1R`
- `ippiFilterGaussianBorder_16s_C1R`
- `ippiFilterGaussianBorder_16s_C3R`
- `ippiFilterGaussianBorder_16s_C4R`
- `ippiCopy_C4C1R`
- `ippiFilterGaussianBorder_16u_C1R`
- `ippiFilterGaussianBorder_16u_C1R`
- `ippiFilterGaussianBorder_16u_C3R`
- `ippiFilterGaussianBorder_16u_C4R`
- `ippiCopy_C4C1R`
- `ippiFilterGaussianBorder_32f_C1R`
- `ippiFilterGaussianBorder_32f_C1R`
- `ippiFilterGaussianBorder_32f_C3R`
- `ippiFilterGaussianBorder_32f_C4R`
- `ippiCopy_C4C1R`
- `ippiFilterGaussianBorder_8u_C1R`
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Appendix C: Removed Functions for Image and Video Processing
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## Appendix C: Removed Functions for Image and Video Processing

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<td>NOTE starting from Intel IPP 9.0, kernel coefficients in the ippiFilterBorder functions are used in direct order, as opposed to the inverse order used in lower versions. Make sure to change the filter order when replacing removed functions with ippiFilterBorder.</td>
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ippiFilterRow32f_16u_AC4R | +ippiFilterBorderInit_32f  
+ippiFilterBorder_16u_C4R (with filter.height=1) |
| ippiFilterRow32f_16u_C1R | **NOTE** Starting from Intel IPP 9.0, kernel coefficients in the ippiFilterBorder functions are used in direct order, as opposed to the inverse order used in lower versions. Make sure to change the filter order when replacing removed functions with ippiFilterBorder.  
ippiFilterRow32f_16u_C1R | +ippiFilterBorderInit_32f  
+ippiFilterBorder_16u_C1R (with filter.height=1) |
| ippiFilterRow32f_16u_C3R | **NOTE** Starting from Intel IPP 9.0, kernel coefficients in the ippiFilterBorder functions are used in direct order, as opposed to the inverse order used in lower versions. Make sure to change the filter order when replacing removed functions with ippiFilterBorder.  
ippiFilterRow32f_16u_C3R | +ippiFilterBorderInit_32f  
+ippiFilterBorder_16u_C3R (with filter.height=1) |
| ippiFilterRow32f_16u_C4R | **NOTE** Starting from Intel IPP 9.0, kernel coefficients in the ippiFilterBorder functions are used in direct order, as opposed to the inverse order used in lower versions. Make sure to change the filter order when replacing removed functions with ippiFilterBorder.  
ippiFilterRow32f_16u_C4R | +ippiFilterBorderInit_32f  
+ippiFilterBorder_16u_C4R (with filter.height=1) |
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<td><code>ippiFilterBorderInit_32f</code> +<code>ippiFilterBorder_8u_C4R</code> (with <code>filter.height</code>=1)</td>
</tr>
</tbody>
</table>
### Removed from 9.0 | Substitution or Workaround
---|---

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  +`ippiFilterBorder_8u_C4R` (with `filter.height`=1) |
| `ippiFilterRow_8u_C1R` | `ippiFilterBorderInit_16s`  
  +`ippiFilterBorder_8u_C1R` (with `filter.height`=1) |
| `ippiFilterRow_8u_C3R` | `ippiFilterBorderInit_16s`  
  +`ippiFilterBorder_8u_C3R` (with `filter.height`=1) |
| `ippiFilterRow_8u_C4R` | `ippiFilterBorderInit_16s`  
  +`ippiFilterBorder_8u_C4R` (with `filter.height`=1) |
## Appendix C: Removed Functions for Image and Video Processing

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<thead>
<tr>
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<td>ippifilterScharrHorizMaskBorder_32f_C1R</td>
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<td>ippiConvert_8s16s ippifilterScharrHorizMaskBorder_8s16s_C1R</td>
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<td>ippifilterScharrVert_32f_C1R</td>
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<td>ippiConvert_8s16s ippifilterScharrVertMaskBorder_16s_C1R</td>
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Starting from Intel IPP 9.0, kernel coefficients in the `ippifilterBorder` functions are used in direct order, as opposed to the inverse order used in lower versions. Make sure to change the filter order when replacing removed functions with `ippifilterBorder`. 
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<td>Use ippiCopy_16s_C4C1R</td>
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<td>Use ippiCopy_16s_C4C1R</td>
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<td>Use ippiCopy_32f_C4C1R</td>
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                          | `+ippiFilterBorder_16u_C3R`                                                             |
| `ippiFilter_16u_C4R`    | `ippiFilterBorderInit_16s`  
                          | `+ippiFilterBorder_16u_C4R`                                                             |
| `ippiFilter_32f_AC4R`   | `ippiFilterBorderInit_32f`  
                          | `+ippiFilterBorder_32f_C4R`                                                             |
| `ippiFilter_32f_C1R`    | `ippiFilterBorderInit_32f`  
<pre><code>                      | `+ippiFilterBorder_32f_C1R`                                                             |
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| ippiPolarToCart_32f32fc_P2C1R | Use ippsCplxToReal_32fc  
+ippiPolarToCart_32fc with loop by row |
| ippiPolarToCart_32sc_C1R | ippiConvert_32s32f  
+ippiPolarToCart_32fc_C1R |
| ippiPolarToCart_32sc_C3R | ippiConvert_32s32f  
+ippiPolarToCart_32fc_C3R |
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| ippiRShiftC_8s_AC4R | Convert to other data type |
| ippiRShiftC_8s_C1IR | Convert to other data type |
| ippiRShiftC_8s_C1R | Convert to other data type |
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| ippiRShiftC_8s_C3R | Convert to other data type |
| ippiRShiftC_8s_C4IR | Convert to other data type |
| ippiRShiftC_8s_C4R | Convert to other data type |
| ippiRemap_16s_P3R | Use ippiRemap_XX_C1R for each plane |
| ippiRemap_16s_P4R | Use ippiRemap_XX_C1R for each plane |
| ippiRemap_16u_P3R | Use ippiRemap_XX_C1R for each plane |
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| ippiRemap_64f_P4R | Use ippiRemap_XX_C1R for each plane |
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## Appendix C: Removed Functions for Image and Video Processing

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## Appendix C: Removed Functions for Image and Video Processing

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### ippj.h

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**Note:** The `ippi` functions listed above are removed from 9.0, and the `Substitution or Workaround` column indicates that there is no direct replacement or workaround for these functions.
### Appendix C: Removed Functions for Image and Video Processing

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### Appendix C: Removed Functions for Image and Video Processing

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### Appendix C: Removed Functions for Image and Video Processing

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Bibliography for Image Processing

This bibliography provides a list of publications that might be helpful to you in using the image processing subset of Intel IPP. This list is not complete; it serves only as a starting point. The books [Rog85], [Rog90], and [Foley90] are good resources of information on image processing and computer graphics, with mathematical formulas and code examples.


[S3TC] *S3 Texture Compression*. http://en.wikipedia.org/wiki/S3TC


[SMPTE314M] SMPTE 314M-2005 for Television - *Data Structure for DV-Based Audio, Data and Compressed Video - 25 and 50 Mb/s*. The Society of Motion Picture and Television Engineers (09/05).

[SMPTE370M] SMPTE 370M-2002 for Television - *Data Structure for DV-Based Audio, Data and Compressed Video at 100 Mb/s, 1080/60i, 1080/50i, 720/60p*. The Society of Motion Picture and Television Engineers (07/02).

[SMPTE370M-06] SMPTE 370M-2006 for Television - *Data Structure for DV-Based Audio, Data and Compressed Video at 100 Mb/s, 1080/60i, 1080/50i, 720/60p, 720/50p*. The Society of Motion Picture and Television Engineers (04/06).


<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>absolute colors</td>
<td>Colors specified by each pixel's coordinates in a color space. Intel Integrated Performance Primitives for image processing use images with absolute colors.</td>
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<tr>
<td>alpha channel</td>
<td>A color channel, also known as the opacity channel, that can be used in color models; for example, the RGBA model.</td>
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<td>arithmetic operation</td>
<td>An operation that adds, subtracts, multiplies, divides, or squares the image pixel values.</td>
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<tr>
<td>color-twist matrix</td>
<td>A matrix used to multiply the pixel components in one color space for determining the components in another color space.</td>
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<tr>
<td>DCT</td>
<td>Acronym for the discrete cosine transform. See Discrete Cosine Transforms in Chapter 10 of this document.</td>
</tr>
<tr>
<td>dilation</td>
<td>A morphological operation that sets each output pixel to the minimum of the corresponding input pixel and its 8 neighbors.</td>
</tr>
<tr>
<td>dyadic operation</td>
<td>An operation that has two input images. It can have other input parameters as well.</td>
</tr>
<tr>
<td>element-wise operation</td>
<td>An element-wise operation performs the same operation on each element of a vector, or uses the elements of the same position in multiple vectors as inputs to the operation.</td>
</tr>
<tr>
<td>erosion</td>
<td>A morphological operation that sets each output pixel to the maximum of the corresponding input pixel and its 8 neighbors.</td>
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<tr>
<td>four-channel model</td>
<td>A color model that uses four color channels; for example, the RGBA color model.</td>
</tr>
<tr>
<td>gray scale image</td>
<td>An image characterized by a single intensity channel so that each intensity value corresponds to a certain shade of gray.</td>
</tr>
<tr>
<td>in-place operation</td>
<td>An operation whose output image is one of the input images.</td>
</tr>
<tr>
<td>linear filtering</td>
<td>In this document, 2D convolution operations.</td>
</tr>
<tr>
<td>linear image transforms</td>
<td>In this document, the discrete cosine transform (DCT).</td>
</tr>
<tr>
<td>MMX™ technology</td>
<td>An enhancement to the Intel® architecture aimed at better performance in multimedia and communications applications. The technology uses four additional data types, eight 64-bit MMX registers, and 57 additional instructions implementing the SIMD (single instruction, multiple data) technique.</td>
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<tr>
<td>monadic operation</td>
<td>An operation that has a single input image. It can have other input parameters as well.</td>
</tr>
<tr>
<td>morphological operation</td>
<td>An erosion, dilation, or their combinations.</td>
</tr>
<tr>
<td>not-in-place operation</td>
<td>An operation whose output is an image other than the input image(s). See in-place operation.</td>
</tr>
<tr>
<td>pixel depth</td>
<td>The number of bits determining each channel intensity for a single pixel in the image.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
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<tr>
<td>pixel-oriented ordering</td>
<td>Storing the image information in such an order that the values of all color channels for each pixel are clustered; for example, RGBRGB... .</td>
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<tr>
<td>planar-oriented ordering</td>
<td>Storing the image information so that all data of one color channel follow all data of another channel, thus forming a separate “plane” for each channel; for example, RRRRRGGGGGBBBBB... .</td>
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<tr>
<td>region of interest</td>
<td>A rectangular image region on which an operation acts (or processing occurs).</td>
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<tr>
<td>RGB</td>
<td>Red-green-blue. A three-channel color model that uses red, green, and blue color channels.</td>
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<tr>
<td>RGBA</td>
<td>Red-green-blue-alpha. A four-channel color model that uses red, green, blue, and alpha (or opacity) channels.</td>
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<tr>
<td>ROI</td>
<td>See identity matrix.</td>
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<tr>
<td>row-major order</td>
<td>The default storage method for arrays in C. Memory representation is such that the rows of an array are stored contiguously. For example, for the array (a[3][4]), the element (a[1][0]) immediately follows (a[0][3]).</td>
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<tr>
<td>saturation</td>
<td>Using saturation arithmetic, when a number exceeds the data-range limit for its data type, it saturates to the upper data-range limit. For example, a signed word greater than (7FFFh) saturates to (7FFFh). When a number is less than the lower data-range limit, it saturates to the lower data-range. For example, a signed word less than (8000h) saturates to (8000h).</td>
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<tr>
<td>Intel® Streaming SIMD Extensions</td>
<td>The enhancement to the Intel architecture instruction set for the next generation processors. It incorporates a group of general-purpose floating-point instructions operating on packed data, additional packed integer instructions, together with cacheability control and state management instructions. These instructions significantly improve performance of applications using compute-intensive processing of floating-point and integer data.</td>
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<td>three-channel model</td>
<td>A color model that uses three color channels; for example, the RGB color model.</td>
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