INTEL® PERCEPTUAL COMPUTING SDK

How to Use the Face Analysis Module
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# Table of Contents

Intel® Perceptual Computing SDK ................................................................. 1
  General Description .............................................................................. 1
Procedure for a Simple Face Analysis Application ..................................... 3
  Project Setup and Configuration ............................................................. 4
  Code Explanation .................................................................................. 4
Procedure for Face Analysis ..................................................................... 7
  1st Step ............................................................................................... 7
  2nd Step .............................................................................................. 7
  3rd Step ............................................................................................... 8
  4th Step .............................................................................................. 9
  5th Step ............................................................................................. 10
Exercise: Putting it all together .............................................................. 11
Intel® Perceptual Computing SDK

The Intel® Perceptual Computing SDK is a library of pattern detection and recognition algorithm implementations exposed through standardized interfaces. The SDK provides a suite of face analysis algorithms including face location detection, landmark detection, face recognition and face attribute detection.

This tutorial shows how to use the SDK for face location detection and landmark detection, and how to write an application for these face analysis modules.

General Description

As shown in Figure 1, the face detection algorithm locates the rectangle position of a face or multiple faces from an image or a video sequence in real-time capture or playback mode.

Figure 1: Face location detection, the number 100 indicates the face ID.

In Figure 2, the landmark detection algorithm locates the 6-point or 7-point landmarks namely, the outer and inner corners of the eyes, the tip of the noise, and the outer corners of the mouth.
Figure 2: Face landmark detection, 7 point landmarks.
Procedure for a Simple Face Analysis Application

It is easy to create a simple face analysis application that will read color video from the camera, detect landmarks, track the faces in each frame, and render them.

The code shown in Figure 3 uses the UtilPipeline utility class for a simplified asynchronous pipeline implementation and the FaceRender class for rendering. The application will first initialize the pipeline and enable landmark detection. Then it will process each frame using the UtilPipeline::LoopFrames function. To observe the results, the application will render each frame with the detection and landmark data using the FaceRender utility.

When the application is running, you should see the color rendering window with the landmark points detected as seen in Figure 2. When you click on the close button on the top, the application closes.

```
#include "util_pipeline.h"
#include "face_render.h"

class FacePipeline: public UtilPipeline {
public:
    FacePipeline(void):UtilPipeline() {
        m_face_render = NULL;
        m_face_render = new FaceRender("Face Viewer");
        EnableFaceLandmark();
    }

    ~FacePipeline() {
        if (m_face_render != NULL) {
            delete m_face_render;
        }

    }

    virtual bool OnNewFrame (void) {
        // face
        PACFaceAnalysis *faceAnalyzer = QueryFace();
        if (faceAnalyzer != NULL) {
            // loop all faces
            m_face_render->ClearData();
            for (int idx = 0; ; idx++) {
                PACFace *face = QueryFace(idx, NULL, 0);
                if (face != NULL) {
                    PACStatus sts = faceAnalyzer->QueryFace(fidx, 0, 0);
                    if (sts < PAC_STATUS_NO_ERROR) break; // no more faces
                    m_face_render->SetLandmarkData (landmark, fid);
                    return (m_face_render->RenderFrame (QueryImage (PACImage::IMAGE_TYPE_COLOR)));
                }
            }
        }

        protected:
            FaceRender* m_face_render;

    private:
        int main(int argc, KKHAR* argv) {
            FacePipeline* pipeline = new FacePipeline();
            pipeline->openFrames();
            delete pipeline;
            return 0;
        }

    }
```

Figure 3: A simple landmark detection code.
Project Setup and Configuration

For project setup and configuration, please follow the steps in the "Getting Started" tutorial to create and configure the project. After completing the project setup and configuration, from the $(PCSDK_DIR)/samples/common/include and $(PCSDK_DIR)/samples/common/src add the “face_render.h” and “face_render.cpp” files to the project, as shown in Figure 4.

![Image: Solution Explorer]

Figure 4: Files to add to the project

Code Explanation

The first step is to use the UtilPipeline class to build a very simple application and define a new class FacePipeline which inherits from this utility class, shown in Example 1. The FacePipeline class is needed to render the face landmarks since this functionality is not a part of the UtilPipeline utility class. So the constructor declares a new FaceRender and the destructor cleans it.
In order to render the landmarks as shown in Example 2, the application will need to implement the `UtilPipeline::OnNewFrame` function that renders face analysis detection data using the `FaceRender` utility. The `OnNewFrame` function uses `UtilPipeline::QueryFace()` to query the face analyzer class. Then the face analyzer uses its `PXCFaceAnalysis::QueryFace()` function to query the detected face. If a face is detected, the application must query the detection data or the landmark data after dynamically casting to the respective module `PXCFaceAnalysis::Landmark`. Finally, a call to `FaceRender::SetLandmarkData` is used for setting the face analysis data that will be rendered when calling the `FaceRender::RenderFrame` routine.
To process each frame of the captured video sequence shown in Example 3, the main function simply calls `LoopFrames()` function to capture and process each frame. The `LoopFrames` function also calls the `OnNewFrame` function for retrieving and rendering the detection data.

```cpp
virtual bool OnNewFrame(void) {
    /* face */
    PXCFaceAnalysis *faceAnalyzer = QueryFace();
    PXCFaceAnalysis::Landmark *landmark =
        faceAnalyzer->DynamicCast<PXCFaceAnalysis::Landmark>();

    // loop all faces
    m_face_render->ClearData();
    for (int fidx = 0; ; fidx++) {
        pxcUID fid = 0;
        pxcU64 timeStamp = 0;
        pxcStatus sts = faceAnalyzer->QueryFace(fidx, &fid,
            &timeStamp);
        if (sts < PXC_STATUS_NO_ERROR) break; // no more faces
        m_face_render->SetLandmarkData (landmark, fid);
    }
    return (m_face_render->RenderFrame(
        QueryImage(PXCImage::IMAGE_TYPE_COLOR)) );
}
```

**Example 2: OnNewFrame Implementation**

A more detailed example of the `PxcFaceAnalysis` module without utilizing the `UtilPipeline` class is given in the following section.
Procedure for Face Analysis

The application uses the following procedure for the face detection operations on a still image or a video sequence:

1st Step

In Example 4, the SDK session is the very first object the face detection application must create to hold all I/O or algorithm modules. This is created by calling the `PXCSession_Create` function. Then the application uses the session functions to create a module instance of the face detection algorithms, which is a part of the `PXCFaceAnalysis` interface. So, the application first creates an instance of the face analysis interface `PXCFaceAnalysis` by calling the `PXCSession::CreateImpl` function with the interface identifier `PXCFaceAnalysis::CUID`.

```c
// Create a session
PXCSession *session;
PXCSession_Create(&session);

// Create Face analyzer interface
PXCFaceAnalysis *faceAnalyzer;
session->CreateImpl(PXCFaceAnalysis::CUID, (void**)&faceAnalyzer);
```

Example 4: creating the module instance

2nd Step

The second step is to configure the `PXCFaceAnalysis` interface as seen in Example 5. The application enumerates supported configurations by using the `QueryProfile` function. Each profile describes a supported configuration. The application sets the desired configuration parameters by using the `SetProfile` function.

```c
// Configure the face analysis interface
PXCFaceAnalysis::ProfileInfo faInfo;
faceAnalyzer->QueryProfile(0, &faInfo);
faceAnalyzer->SetProfile(&faInfo);
```

Example 5: Module configuration

Profile '0' is the first profile and is usually the default profile of the interface. The `PXCFaceAnalysis::ProfileInfo` describes the video streams capture info and general parameters that are common to the different face analysis modules (detection, landmark, etc.). Thus, after `QueryProfile`, the capture device and video streams can be configured for face
analysis procedures according to the enumerated \texttt{PXCFaceAnalysis::ProfileInfo}. Therefore, the \texttt{PXCFaceAnalysis} interface and capture device configurations need to be done jointly as follows in Example 6:

```c
// Configure the face analysis interface
PXCFaceAnalysis::ProfileInfo faInfo;
faceAnalyzer->QueryProfile(0, &faInfo);

// Find capture device
UtilCaptureFile capture(session,0,0);
capture.LocateStreams(&faInfo.inputs);

// Set the face analysis interface
faceAnalyzer->SetProfile(&faInfo);
```

**Example 6: Locate the video stream**

Here the \texttt{UtilCaptureFile} tool is utilized for a simplified approach of using the capture devices and setting the appropriate capturing stream.

### 3\textsuperscript{rd} Step

At this point, the application may selectively configure a few or all of the analysis modules, such as face location detection, face landmark detection, and other implemented face analysis modules. The procedure of configuring these modules is similar. As an example, for configuring the face location detection, the application derives the detection interface from the \texttt{PXCFaceAnalysis} interface by using the \texttt{DynamicCast} function, and then calls the \texttt{QueryProfile} and \texttt{SetProfile} functions shown in Example 7.

```c
// Configure the face detector interface
PXCFaceAnalysis::Detection *faceDetector;
faceDetector=faceAnalyzer->DynamicCast<PXCFaceAnalysis::Detection>();

// Set the face detector profile
PXCFaceAnalysis::Detection::ProfileInfo dInfo={0};
faceDetector->QueryProfile(0, &dInfo);
faceDetector->SetProfile(&dInfo);
```

**Example 7: Detection module configuration**

The \texttt{PXCFaceAnalysis::Detection::ProfileInfo} describes the supported view angle of the detection algorithm. The default \texttt{ViewAngle} is set to \texttt{VIEW_ANGLE_MULTI}, which is equivalent to the bit-OR’ed value of view angle 0 degrees, 45 degrees, frontal (facing the camera), 135 degrees, and 180 degrees. Similarly, the same steps are followed for configuring the face landmark detection module as presented in Example 8.
4th Step

The application performs face analysis by calling the `ProcessImageAsync` function. If the face analysis is on a still image, the application provides the image at the input. If the face analysis is on a video sequence, the application provides one video frame at a time in the main loop. The `ProcessImageAsync` function returns an SP, which the application can synchronize with before retrieving the analysis results. This is shown in Example 9 as follows:

```cpp
// Configure the face detector interface
FXCFaceAnalysis::Landmark *landmarkDetector;
landmarkDetector=faceAnalyzer->DynamicCast<FXCFaceAnalysis::Landmark>();

// Set the face landmark detector profile
FXCFaceAnalysis::Landmark::ProfileInfo lInfo={0};
landmarkDetector->QueryProfile(1, &lInfo);
landmarkDetector->SetProfile(&lInfo);
```

Example 9: Asynchronous processing

For each captured frame, an asynchronous pipeline is executed that consists of reading a frame and then processing the current frame using any of the configured face analysis algorithms. Note that nothing is processed in the asynchronous pipeline until the Sync Points are synchronized by calling the `SynchronizeEx` function. The Asynchronous pipeline for Face Landmark detection is shown in Figure 5.
5th Step

To retrieve the face detection results, the application needs to use `QueryData` function in the Detection interface shown in Example 10. `QueryFace` is first called to enumerate all the detected faces during face analysis processing.

```cpp
for (int fidx = 0; fidx++) {
    pxcUID fid = 0; pxcU64 timeStamp = 0;
    sts = faceAnalyzer->QueryFace(fidx, &fid, &timeStamp);
    if (sts < PXC_STATUS_NO_ERROR) break; // no more faces detected

    PXCFaceAnalysis::Detection::Data face_data;
    faceDetector->QueryData(fid, &face_data);
}
```

**Example 10: Query the detection data**

To retrieve the face landmark detection results, the application needs to `QueryData` for the labels in the already set profile, as follows in Example 11:
Example 11: Retrieve the face Landmark data

Exercise: Putting it all together

After explaining key parts of the application above, run the landmark detection sample code shown in Example 12. Copy the code and construct a project following the section “Project Setup and Configuration” explained previously in this tutorial. Similarly, add the following files shown in Figure 6 to the project.

```c
for (int fidx = 0; ; fidx++) {
    pxCUID fid = 0; pxCU64 timeStamp = 0;
    sts = faceAnalyzer->QueryFace(fidx, &fid, &timeStamp);
    if (sts < PXC_STATUS_NO_ERROR) break; // no more faces detected

    PXCFaceAnalysis::Landmark::ProfileInfo lInfo={0};
    landmark->QueryProfile(&lInfo);

    PXCFaceAnalysis::Landmark::LandmarkData data[7];
    pxcStatus sts=landmark->QueryLandmarkData(fid,lInfo.labels,&data[0]);
}
```

Figure 6: Project files to be added
#include "pxcsession.h"
#include "pxccapture.h"
#include "pxcsmartptr.h"
#include "face_render.h"
#include "util_capture_file.h"
#include "util_cmdline.h"
#include "pxcface.h"

int wmain(int argc, wchar_t* argv[])
{
    // Create a session
    PXCSmartPtr<PXCSession> session;
    pxCStatus sts=PXCSession_Create(&session);
    if (sts<PXC_STATUS_NO_ERROR) {
        wprintf_s(L"Failed to create the SDK session\n");
        return 3;
    }
    UtilCmdLine cmdl(session);
    if (!cmdl.Parse(L"-sdname-nframes-file-record",argc,argv)) return 3;

    // Init Face analyzer
    PXCSmartPtr<PXCFaceAnalysis> faceAnalyzer;
    sts=session->CreateImpl(cmdl.m_iuid, PXCFaceAnalysis::CUID,
                            (void**)&faceAnalyzer);
    if (sts<PXC_STATUS_NO_ERROR) {
        wprintf_s(L"Failed to locate a face module");
        return 3;
    }

    // Retrieve the input requirements
    PXCFaceAnalysis::ProfileInfo faInfo;
    faceAnalyzer->QueryProfile(0, &faInfo);

    // Find capture device
    UtilCaptureFile capture(session,cmdl.m_recordedFile,cmdl.m_bRecord);
    if (cmdl.m_sdname) capture.SetFilter(cmdl.m_sdname);
    /*L"Integrated Camera"*/
    sts=capture.LocateStreams(&faInfo.inputs);
    if (sts<PXC_STATUS_NO_ERROR) {
        wprintf_s(L"Failed to locate an input device that matches input for face analysis\n");
        return 3;
    }
    faceAnalyzer->SetProfile(&faInfo);

    // Create detector instance
    PXCFaceAnalysis::Detection *faceDetector=faceAnalyzer->DynamicCast<PXCFaceAnalysis::Detection>();
    if (!faceDetector) {
        wprintf_s(L"Failed to locate the face detection functionality\n");
        return 3;
    }
}
// Create landmark instance
PXCFaceAnalysis::Landmark landmarkDetector=landmarkDetector=faceAnalyzer->DynamicCast<PXCFaceAnalysis::Landmark>();
if (!landmarkDetector) {
    wprintf_s(L"Failed to locate the face landmark functionality\n");
    return 3;
}

// Set landmark profile
PXCFaceAnalysis::Landmark::ProfileInfo lInfo={0};
landmarkDetector->QueryProfile(0, &lInfo);
landmarkDetector->SetProfile(&lInfo);

// Create Renderer
PXCSmartPtr<FaceRender> faceRender(new FaceRender(L"Landmark Detection Sample"));

int fnum;
for (fnum=0; fnum<cmdl.m_nframes; fnum++) {
    PXCSmartArray<PXCImage> images;
    PXCSmartSPArray sps(2);

    ///* read and process frame */
    sts = capture.ReadStreamAsync(images, &sps[0]);
    if (sts<PXC_STATUS_NO_ERROR) break; // EOF

    sts = faceAnalyzer->ProcessImageAsync(images, &sps[1]);
    sts = sps.SynchronizeEx();
    if (sps[0]->Synchronize(0)<PXC_STATUS_NO_ERROR) break; // EOF

    // loop all faces
    faceRender->ClearData();
    for (int fidx = 0; ; fidx++) {
        pxcUID fid = 0;
        pxcU64 timeStamp = 0;
        sts = faceAnalyzer->QueryFace(fidx, &fid, &timeStamp);
        if (sts < PXC_STATUS_NO_ERROR) break; // no more faces

        // Query face detection results
        PXCFaceAnalysis::Detection::Data face_data;
        faceDetector->QueryData(fid, &face_data);
        faceRender->SetDetectionData(&face_data);

        // Query landmark points
        faceRender->SetLandmarkData(landmarkDetector, fid);
        faceRender->PrintLandmarkData(landmarkDetector, fid);
    }
    wprintf_s(L"timestamp=%I64d, frame=%d\n", timeStamp, fnum);
}

if (!faceRender->RenderFrame(images[0])) break;
return 0;
Running the application will output the face detection window and landmarks shown in Figure 7. Note that the `FaceRender` utility is used to render the output frame with the face detection results. The functions `FaceRender::SetDetectionData` and `FaceRender::SetLandmarkData` are used to set the face detection/landmark data and the function `FaceRender::RenderFrame` is used to render each frame with the set face detection data.

![Figure 7: Landmark detection results](image-url)