**YASK: Yet Another Stencil Kernel**

A Software Framework for HPC Stencil Optimization

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**Background:** Stencil Computation

• Stencils: Iterative kernels that update elements in one or more N-dimensional grids using a fixed pattern of computation on neighboring elements.

• Fundamental algorithm in many scientific simulations, commonly used for finding numerical solutions to differential equations using finite-difference methods (FDM).

**AWP-OCD: Anelastic Wave Propagation—Olsen, Day, Cui**

• Software that simulates seismic wave propagation after a fault rupture

• Widely used by the Southern California Earthquake Center (SCEC) community

**AWP-OCD-OS**

• First ever open source release in 2016 (BSD-2 license), including port to Intel® Xeon Phi™ processor, under development by San Diego Supercomputer Center (SDSC) at Univ. of CA, San Diego (UCSD)

Combined hazard map of the Holyoke (15.4 sA, CWM-54.26) and 17.3 (Central CA, CGA-06). Citations show 2 seconds period spectral acceleration (SAS) for 1% exceedance probability in 50 years. AWP-OCD simulations are used to generate hazard maps. See https://cscr.ucsb.edu/aspke/Study_17.3_Data_Products

**Example Application**

Example YASK Feature: Automatic Vector Folding

- Provided performance-evaluation binary
- Stencil compiler
- Optimized stencil calculation code
- Stencil specification code
- Compiler
- Other C++ code
- Nested loops with OpenMP, etc.
- Performance measurements
- Load library
- Stencil-based HPC application
- Your application data
- Your application results
- APIs
- Your application results
- Simple scalar stencil code transformed into high-performance library

Simple 2-D stencil code transformed into high-performance library

**Background:** Example Application

- 2, 2, 5
- 3, 5
- 4, 8
- 4, 5
- 4, 9

**Background:** Turning Models Into Code

1. Geophysicists use differential equations to represent velocity and stress of rock and soil during an earthquake

2. Derivatives are approximated in both time and space (only x dimension shown here)

3. Equations are expanded to finite-difference stencils (this is one of 15 stencils for AWP-OCD staggered-grid formulation)

4. Stencils are coded and tuned for HPC clusters (focus of YASK)

**Example YASK Feature: Automatic Vector Folding**

Example of traditional 1-D vectorization

- Logical indices in 20x8 64-bit SIMD in a dimension

Example of 2-D “vector folding”

- Logical indices in 10x18 elements SIMD in a dimension

Stencil performance improvements up to 1.6x observed due to vector folding*

**AWP-OCD content provided courtesy of San Diego Supercomputing Center (SDSC) and University of California at San Diego (UCSD)**

- Contributions include Alex Brown (SDSC), Yiheng Cui (SDSC), Alex Heinrich (Intel), and Josh Tobin (UCSD)

- The collaboration at SDSC/UCSD is supported by NSF through award ACI-1450501 and by Intel through the Intel® Parallel Computing Center (IPCC) project "Accurate and Efficient Earthquake Simulations on Intel® Xeon Phi™ Processors.

Learn more about YASK and vector folding

- C. Yount, "Vector Folding: Improving Stencil Performance via Multi-Dimensional SIMD-vector Representation," 2016 45th SIGARCH Computer Performance 
  
  Learn more about AVX and Vector Folding

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Learn more about AWP


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