HIGH PERFORMANCE COMPUTING MODERNIZATION PROGRAM

RESEARCH PROJECT #: HPCMP-HIP-24-023

Leveraging TensorFlow for Accelerated Matrix-Vector Operations in a Finite Element Software

About AFRL:

Air Force Research Laboratory (AFRL) is a scientific research organization operated by the United States Air Force Materiel Command. AFRL is dedicated to leading the discovery, development, and integration of aerospace warfighting technologies, planning, and executing the Air Force science and technology program, and providing warfighting capabilities to United States air, space, and cyberspace forces.

The composites performance team at the Air Force Research Laboratory Materials and Manufacturing Directorate uses a combination of novel and high-impact experiments, in-house high-fidelity HPC simulation software, and machine learning to characterize and predict the performance of current and emerging materials.

RESEARCH LOCATION: Wright-Patterson AFB, OH

PROJECT DESCRIPTION:

The overall goal for the project is to explore linear algebra frameworks developed outside of the classical scientific computing community, assessing if they more efficiently leverage GPUs and other accelerators. The approach for the project includes 1) learning the TensorFlow C++ API, 2) crafting wrappers to allow our in-house finite element method software to use their linear algebra kernels, and 3) benchmark the performance of library in the context of physics-based simulations.

To achieve the goals of the project, the intern will:

Week 1: Complete in-processing, obtain access to a DoD HPC system, and learn how schedule simulations on an HPC system.

Week 2: Learn about TensorFlow's linear algebra kernels and their C++ API.

Week 3: Learn about how in-house finite element framework (SPAWC) calls linear algebra operations.

Weeks 4-5: Write a thin wrapper library to allow SPAWC to call TensorFlow's kernels instead of MKL or PETSc.

Weeks 6-8: Measure performance using a benchmark simulation with TensorFlow, MKL, and Eigen as the linear algebra backends.

Weeks 9-10: Author a report summarizing the work, document all code, and give a research presentation to research team and another to the broader AFRL RX community.

In addition to the activities related to the project directly, the intern will have the opportunity to attend seminars focused on computing, machine learning, and material science; attend technical meetings across a variety of disciplines; participate in tours in the computing and material labs; and network with experts across disciplines.

These activities will give the intern the opportunity to lead a research project typical to those in government labs and develop a deep understanding of heterogeneous computing. If desired, the intern can choose to pursue DoD technical report.

ANTICIPATED START DATE:

May 2024 – Exact start dates will be determined at the time of selection and in coordination with the selected candidate.

QUALIFICATIONS:

The ideal candidate should have interest in continuing to pursue an education or career in computer science focused on scientific computing and be:

- Enrolled in a STEM field coupled with a strong computing background
- Proficient in at least one well-known programming language (Python, C++, etc.)

Qualifications that are not required but would be helpful include:

- Familiarity with C++
- Familiarity with Git
- Familiarity with composites performance (AFRL/RXN)

ACADEMIC LEVEL:

Degree received within the last 60 months or currently pursuing:

- Bachelor's
- Master's
- Doctoral

DISCIPLINE NEEDED:

- Chemistry and Materials Science
- Computer, Information, and Data Sciences
- Engineering
- Mathematics and Statistics
- Physics
- Science and Engineering related