HIGH PERFORMANCE COMPUTING MODERNIZATION PROGRAM

RESEARCH PROJECT #: HPCMP-HIP-24-016

Exploration of Novel Machine Learning Surrogate Models for Structural Topology Optimization

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.

As part of AFRL's Materials and Manufacturing Directorate, the Digital Manufacturing Research Team studies the intersection of digital & simulation capabilities and advanced manufacturing technologies, working in areas including human-machine teaming, machine intelligence, and process-informed design. Motivated by recent advances in manufacturing processes such as additive, this project will support the team's interests in fully leveraging manufacturing capabilities during the design stage to improve future Air Force systems from the component level.

RESEARCH LOCATION: Wright-Patterson AFB, OH

PROJECT DESCRIPTION:

The objectives of the internship center around tuning the performance of two forms of ML surrogate models for topology optimization with which AFRL has preliminary results: (1) tuning diffusion model performance where the objective is to obtain a variety of outputs for a given problem using input biasing techniques and (2) tuning PCANet hyperparameters to maximize performance when scaling up the resolution of the output.

Weeks 1-2: Intro to DSRC, Python, TensorFlow, basics of deep learning for topology optimization

Weeks 3-4: Learn AFRL code base for TO and get comfortable running it on HPC

Weeks 5-8: Perform parameter study using the diffusion model [primarily, biasing magnitude] and PCA-Net [primarily, # of reduced dimensions]

Weeks 9-10: Concluding activities such as documentation, report prep, RX poster session

Deep (machine) learning and generative modeling are techniques used broadly throughout a range of technical disciplines, including engineering, materials science, bioinformatics, and a growing number of others. By studying the underlying mechanisms by which these models operate and gaining experience improving upon preliminary model configurations, the intern will develop skills desirable for future employment as technical disciplines continue to adopt digital technologies/ML moving forward.

The practical experience tuning and improving models for better performance on a particular problem will complement theory-heavy learning during their classes and prepare the intern for a future in which COTS ML models are more frequently used as starting points for model tuning for unique problems using minimal additional data. Skills developed will include several Python packages that are popular across disciplines, including TensorFlow, NumPy, Matplotlib, and Scikit-learn, as well as Linux/bash.

In addition to these project-specific activities, the AFRL Materials and Manufacturing Directorate (AFRL/RX) provides several opportunities for students to learn about STEM research areas and career pathways. For example, the directorate organizes the weekly RX101 technical seminar series during the summer where the mission and technical overview of each research team is presented. RX also has a machine learning working group and seminar series, called "Miracle", that the intern will be encouraged to engage. The AFRL/RX summer student poster session also provides an opportunity for the students to interact with AFRL researchers and showcase their summer research activities.

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 will be currently pursuing a degree in a field such as physics, engineering, computer science, or statistics, and show interest in applying digital tools to engineering problems. Previous coding experience (any language) is highly encouraged, with Python experience preferred.

ACADEMIC LEVEL:

Degree received within the last 60 months or currently pursuing:

- Bachelor's
- Master's
- Doctoral

DISCIPLINE NEEDED:

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