HIGH PERFORMANCE COMPUTING MODERNIZATION PROGRAM

RESEARCH PROJECT #: HPCMP-HIP-26-037

Large Scale, Data-Driven Design for Manufacturing

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 additives, 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:

In fields such as the design of aerospace components, design spaces tend to be very large but have overlaps and patterns -- many designs may give similar performance, and non-intuitive paths may connect regions of low and high performance. Conventional design optimization approaches tend to neglect these factors, leading to repetitive optimization studies that do not leverage the valuable results of past studies for improvements in performance and computational efficiency. These challenges are accentuated when manufacturability is considered an additional performance criterion, because manufacturability assessments entail additional complexity in terms of computational cost and high sensitivity to slight design changes.

This project seeks to build large databases of high-performing designs on representative DAF-relevant design challenges and then explore the resulting databases using appropriate machine learning techniques, such as unsupervised dimensionality reduction, Gaussian Process regression, or artificial neural networks.

This project will consist of three phases. Flexibility in timing will be exercised by prior knowledge/skillset.

Phase 1: Problem Selection

Mentor has multiple (Distro A) design problem examples that are candidates for improvement. The intern will consider/modify options and determine the problem of greatest interest. The intern will also become familiar with in-house code written at AFRL, especially while HPC access is finalized. Estimated completion time: two weeks.

Phase 2: Database Construction

The intern will modify the appropriate code mentioned above for deployment on the HPC. At the same time, the parameters for the design database will be determined (i.e. what designs the database should include). This phase will conclude with the acquisition of those designs through optimization techniques on the HPC. Estimated completion time: two weeks.

Phase 3: ML-Based Exploration/Surrogate Modeling

Using the above database, the landscape of ML models will be considered according to the mentor suggestions, and these techniques will be used to draw insight from the database. Significant AFRL code exists for these activities, and this code will be repurposed and modified by the intern. Estimated completion time: four weeks.

The final two weeks will be reserved for final preparation of presentation.

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-heaving 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. Particular 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 interns 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 interns to interact with AFRL researchers and showcase their summer research activities.

ANTICIPATED START DATE:

May/June 2026 – 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 computer science, physics, engineering, or statistics/mathematics, and show interest in applying digital tools to engineering problems. Candidates with coding knowledge (any language) are highly encouraged to apply, with Python knowledge is strongly 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
- Mathematics & Statistics
- Physics
- Engineering