HIGH PERFORMANCE COMPUTING MODERNIZATION PROGRAM

RESEARCH PROJECT #: HPCMP-HIP-24-007

Surrogate Models for 3D Aerodynamics Effects for Rotorcraft Applications using CFD data

About DEVCOM ARL:

The DEVCOM Army Research Laboratory conducts basic and applied research for the Army. Its mission is to operationalize science for transformational overmatch. The basic research conducted at the laboratory leads to capabilities for soldiers to fight and win on the battlefield. The Vehicle Applied Research Branch specifically conducts experimental and computational research in rotary-wing and other vertical lift technologies at both the manned and unmanned scales.

RESEARCH LOCATION: Aberdeen Proving Ground, MD

PROJECT DESCRIPTION:

Surrogate models will be developed to predict the 3D aerodynamics effects for rotorcraft applications using HPCMP CREATE-AV (Helios) to produce training data at various operating conditions for a variety of blade geometries. The resulting model can be used to enhance the accuracy of Helios Reduced Order Aerodynamics Model (ROAM) to predict the tip loss and blade vortex interaction effects for wide variety of blade geometries.

Currently available aerodynamics models for rotorcraft applications are limited to either low order (based on 2D airfoil tables, empirical model) or high order (3D CFD simulations) models. In the proposed research, surrogate models will be developed by combining the information from the low order models and high order CFD results. In particular, the surrogate models will use CFD results as training data to obtain a 3D flow correction to the basic low-order model for various blade geometries and operating conditions. The intern will develop a blade geometry parameterization scheme, build blade meshes, generate Helios models, run/process Helios models, build a training dataset, select types of surrogate models, and train/evaluate surrogate models. Adaptive sampling of the variables will be used to build the dataset. Mentor is responsible for selecting representative rotorcraft configurations to be used as the database for the training data. Examples of the surrogate models that will be evaluated are Gaussian Process Regression and Deep Neural Networks. The surrogate models will be evaluated to assess the performance, accuracy, and applicability of the models for various applications.

The Intern will learn how to perform Helios simulations using a variety of HPC tools including Helios (CREATE-AV) and Capstone (CREATE-FT). The intern will be sent to attend Capstone and Helios trainings if offered by the CREATE program. The interns will be trained to perform the simulations and be allowed to complete the research task with guidance from the mentors. The intern will learn how to determine feature importance (for blade geometry parameterization), adaptive sampling of the variables, automatically generate blade meshes, build/run/process Helios models, collect CFD data into a database for training data, and select/train/evaluate surrogate models (based on several metrics including accuracy, complexity, and computational efficiency).

At the conclusion of the project, the interns will present the research findings to researchers in the mentor organization. In the first two weeks of the internship, the mentor will train the intern on software, methods, concepts related to the tasks (Helios, Capstone, surrogate modeling overview). Next the intern will be given a series of small tasks to learn how to perform Helios simulations on the HPC systems and basic surrogate modeling tasks. Throughout the 10-week period, a daily informal meeting will be scheduled to assess the intern progress and fill in the knowledge gaps for the intern. The intern and mentor will be co-located in the same building which allows for convenient formal and informal daily interactions.

Tentative program schedule (10-weeks):

Weeks 1-3: Training on software and development of CFD meshes, surrogate modeling, blade parameterization

Weeks 4-7: Develop CFD simulation models/surrogate models

Weeks 8-10: Complete computational runs, train surrogate models, prepare HIP deliverables

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 would be a master's or doctoral student in aerospace engineering with education or experience in:

- CFD
- Machine learning/surrogate modeling
- Python
- TernsorFlow

ACADEMIC LEVEL:

Degree received within the last 60 months or currently pursuing:

- Master’s
- Doctoral

DISCIPLINE NEEDED:

- Computer, Information, and Data Science
- Engineering
- Science & Engineering-related