Advancing Bathymetry Inversion with Physics-Informed + Generative AI

About ERDC

The U.S. Army Engineer Research and Development Center (ERDC) helps solve our nation's most challenging problems in civil and military engineering, geospatial sciences, water resources, and environmental sciences for the Army, Department of Defense, civilian agencies, and our Nation's public good. Our vision is to become the world's premier public engineering and environmental sciences research and development organization.

As one of the most diverse engineering and scientific research organizations in the world, ERDC conducts research and development in support of the Soldier, military installations, and the Corps of Engineers' civil works mission, as well as for other federal agencies, state and municipal authorities, and with U.S. industries through innovative work agreements. ERDC operates more than $2 billion in world class facilities at seven labs located in four states with more than 2,600 employees to administer an annual research program exceeding $2 billion.

RESEARCH LOCATION: Vicksburg, MS

PROJECT DESCRIPTION:

Accurate seafloor maps (bathymetry) are vital for coastal navigation, disaster response, and planning, yet classical inversion methods are slow and data hungry. This project applies advanced AI/ML techniques such as physics-informed neural networks, deep generative models, and Bayesian inversion to provide real-time bathymetry estimates with quantified uncertainty from sparse, noisy hydrodynamic data. Experiments will run on GPU-accelerated high-performance computing (HPC) systems.

The objective is to enhance in-house software for bathymetry inversion by applying state-of-the-art techniques and the latest advances in AI/ML. Existing tools with implementation guidance, and proven HPC workflows will be leveraged to ensure rapid development and success. Specifically, the goal is to build on existing physics-informed neural network frameworks, deep generative modeling tools, and advanced sampling methods for Bayesian inversion. A literature review will be conducted to integrate recent methods and propose novel improvements. Automated hyperparameter tuning and network design tools will be applied to accelerate development.

HEC Tools:

- HPC systems
- GPUs
- Schedulers (SLURM/PBS)
- ML frameworks (PyTorch, TensorFlow, JAX)
- CFD models
- Auto ML

Under the guidance of mentors, the intern will participate in an AI/ML research experience applying physics-informed neural networks, deep generative models, and Bayesian methods for bathymetry inversion, and networking with ERDC researchers to explore novel ideas and produce reproducible results.

The intern will explore PyTorch, TensorFlow, and JAX and practice implementing on HPC/GPU systems. Early activities include onboarding to HPC/GPU workflows, reviewing key literature, and examining existing PINN, generative, and Bayesian inversion codebases. The intern will collect, generate, and curate synthetic datasets, design experiments, and analyze accuracy and uncertainty using established metrics and visual summaries. Throughout the experience, the intern will research algorithm variants, evaluate model behavior, and document findings in a reproducible, well-organized manner (notebooks, configuration files, and read-as-you-run guides).

Mentoring and networking will include regular meetings with the mentor and co-mentor, weekly roundtable discussions, and interactions with ERDC researchers across laboratories; laboratory and HPC facility tours will be included as available and permitted. The activities are appropriately challenging, progressing from data processing and baseline replications to automated tuning and model improvements without requiring prior specialization. By week 10, the intern will present a reproducible codebase built on existing tools, a short technical brief or poster, and a lightweight demo suitable for internal dissemination.

Projected Schedule:

Week 1: Onboarding, data/env setup, literature review.
Week 2: Reproduce PINN baseline.
Week 3: Add UQ to PINN baseline.
Week 4: Reproduce Deep Generative-based Bayesian Inversion (DGBI) baseline.
Week 5: Automated tuning and network design; ablations.
Weeks 5-6: Apply novel techniques to improve the existing frameworks.
Weeks 7-8: Compare PINN and DGBI.
Weeks 9-10: Clean code and document.

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:

A successful candidate should be pursuing a graduate degree and have previous research knowledge related to AI/ML, but exceptions can be made for strong candidates that meet the rest of the requirements. Additionally, the candidates should be passionate about learning and solving challenging problems. Skills in one or more of the following would be advantageous:

- Computer science and programming (preferably Python)
- Machine Learning
- Numerical Modeling
- Computational Fluid Mechanics
- Advanced physics

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