Stage: Hybrid - AI-augmented - iterative methods

Research project

Scientific machine learning (SciML) has significantly enhanced traditional numerical methods by streamlining computational modeling and offering cost-effective surrogate models. However, SciML surrogates suffer from the absence of explicit error control and the lack of reliability in practice. This project aims to address this limitation by developing novel hybrid iterative methods that combine the efficiency of SciML with the reliability of standard numerical approaches. In particular, we will investigate how to enhance trust-region algorithms for nonlinear optimization using operator learning approaches, e.g., DeepONets or FNOs.

Scientific environment

The candidate will join the international chair HAILSED at ANITI and the IRIT Laboratory (APO team) at ENSEEIHT (Toulouse-INP). The HAILSED chair, focusing on hybridizing AI and large-scale numerical simulations for engineering design, offers valuable opportunities to engage with experts in (scientific) machine learning, applied mathematics, scientific computing, numerical simulations, and high-performance computing (HPC). The candidate will also actively collaborate with researchers from ISAE-SUPAERO and IRT Saint Exupéry, enhancing their scientific development and interdisciplinary research profile.

Candidate's profile

The candidate should be interested in computational science, applied mathematics, or related fields. Additionally, experience in the following areas is highly beneficial:

- Programming in Python
- Practical deployment of (Sci)ML applications within PyTorch, Tensorflow, JAX, etc.
- Knowledge of numerical optimization and iterative methods for solution of linear systems of equations (stationary iterative methods, Krylov methods)
- Working proficiency in English.

The application

Interested candidates are required to submit an application that includes the following:

1. A comprehensive CV
2. A motivation letter detailing the applicant's research interests and reasons for applying

Please send your complete application in one single PDF file to Alena Kopaničáková (alena.kopanicakova@toulouse-inp.fr). The call is open until the position is filled.

Related literature

1. Enrui Zhang, Adar Kahana, Alena Kopaničáková, Eli Turkel, Rishikesh Ranade, Jay Pathak, and George Em Karniadakis. Blending neural operators and relaxation methods in pde numerical solvers. *Nature Machine Intelligence*, pages 1–11, 2024

2. Alena Kopaničáková and George Karniadakis. DeepONet Based Preconditioning Strategies for Solving Parametric Linear Systems of Equations. *Accepted for publication in SIAM Journal on Scientific Computing*, 2024