Imperial College London

Natural Environment Research Council

2024_27_ESE_GW: Machine learning for subsurface multiphase flow in the energy transition

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Our generation is facing unprecedented challenges in climate change and sustainability. Many countries have pledged to take rapid action to reach net zero by 2050, which calls for a portfolio of innovative, interdisciplinary, and scalable solutions to reduce greenhouse gas emissions and accelerate the transition towards a low-carbon society. Among these solutions, subsurface geological formations play a vital role in two aspects. First, when combined with carbon capture technologies, the subsurface porous rock formations provide a cost-effective and prevalent resource for the permanent storage of CO2. Second, subsurface formations possess the potential to provide terawatt-hours-scale energy storage to support a renewable-based energy system.

The modeling of multiphase flow through porous media is essential for the scale-up of both CO2 storage and energy storage. It involves solving mass and energy conservation equations with fine spatial and temporal discretization to capture these flow processes. Meanwhile, the inherent uncertainty in property distributions of heterogeneous subsurface porous media requires repetitive forward simulation to aid decisions, which results in high computational demands.

Machine learning has been demonstrated to be a powerful tool for making predictions in these complex problem domains, providing a faster alternative to running numerical simulations. This project aims to develop machine-learning algorithms for modeling multiphase flow simulations in the context of the energy transition. This project will revolve around tackling three challenges to advance the frontier in AI for scientific computing: (1) prediction of fluid flow with coupled physics, (2) prediction of multiscale responses, and (3) generalizable algorithms and foundation models for subsurface flow.

The project will be hosted multi-disciplinarily by the Earth Sciences and Engineering department and Imperial-X (I-X) Center for AI, with extensive opportunities to collaborate with scientists from both domains. The Ph.D. student will get hands-on experience with various AI-based scientific computing approaches, including neural networks, neural operators, and graph learning. Experiences with computer programming, fluid mechanics, and the broad context of machine learning are highly appreciated; experiences with reservoir simulation are recommended yet optional. The successful candidate will be encouraged to develop their profile across both the machine learning and the earth science community, with opportunities to promote their work at conferences and journals in both domains.

Interested candidates are encouraged to reach out to Dr. Gege Wen at g.wen@imperial.ac.uk prior to the admission deadline.