Physics-informed machine learning for subsurface reservoir dynamics modelling

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Project description

Evaluation of subsurface reservoir dynamics associated with geological carbon storage is of paramount importance to safe project operations and long-term containment of CO_2. Conventional partial differential equation-based solvers for reservoir modelling suffer from high computational costs for revealing small-scale high-fidelity details of 3D complex reservoir systems. One of new focuses of numerical modelling involves incorporating deep learning techniques to the development of combined physics-data models, which are expected to integrate the strengths of the physical interpretability of underlying equations and excellent learning capability of purely data-driven machine learning techniques. The physics-informed neural network is such as model, which uses a deep neural network to approximate the solution of differential equations, and is trained using a loss function to penalise the residual of underlying equations.

The objective of this research is to develop a physics-informed neural network to model the subsurface reservoir behaviour (fluid flow and solid deformation) in response to geological carbon storage. The neural network to be developed will yield physically interpretable results with accuracy comparable with purely data-driven neural networks. This neural network is expected to find broad engineering applications beyond geological carbon storage, such as deep geothermal systems, hydrogen storage, and nuclear waste disposal.

The applicant will focus on a representative subsurface fluid injection problem, where both (1) the analytical solution, and (2) a standard data-driven neural network are available. The applicant will make use of the existing standard data-driven neural network architecture to train a physics-based neural network for modelling the subsurface reservoir dynamics, and compare model results against the existing analytical solution and the standard data-driven neural network solution. The applicant will have frequent contact with the supervisor, both in person and online.

Job requirements

Applicants for this project should have a basic understanding of machine learning and have programming experience using Python. Affinity with partial differential equations would be helpful.