CO2 Distribution Prediction Using Machine Learning Based Proxy Model in Geological Carbon Sequestration

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Abstract

Numerical Simulation of subsurface flow is one of the most import part in the carbon sequestration project because of its strong ability of risk assessment and uncertainty quantification. Monte Carlo simulation is the most widely used method, but is limited due its high computation costs, especially for large-scale simulations. Physics-based data-driven surrogate model, which establishes the inner input-output relationships and gives the simulation result as numerical simulation did with high accuracy in a few seconds, provides an opportunity to overcome this shortage. In this work, we formulate a conditional deep convolutional generative adversarial network (cDC-GAN) surrogate model to learn the dynamic functional mappings in multiphase models. The main strength of the cDC-GAN is that it includes a self-training scheme for improving the quality of generative modeling in a game theoretic framework, without requiring extensive statistical knowledge and assumptions on input data distributions. In particular, our cDC-GAN model is designed to learn cross-domain mappings between high-dimensional input (e.g., permeability) and output (e.g., phase saturations) pairs, with the ability to incorporate conditioning information (e.g., prediction time). As a use case, we demonstrate the performance of cDC-GAN for predicting the migration of carbon dioxide (CO2) plume in heterogeneous carbon storage reservoirs, which has both numerical and practical significance because of the safe storage requirements now mandated in many countries. Results show that cDC-GAN achieves high accuracy in predicting the spatial and temporal evolution patterns of the injected CO2 plume, as compared to the original results obtained using a

compositional reservoir simulator. It provides a general framework for developing surrogate models and conducting uncertainty analyses for a wide range of physics-based models used in both groundwater and subsurface energy exploration applications.

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