Contribution ID: **187** Type: **Oral Presentation**

CO2 Leakage Detection using Optimized Deep Learning

Monday, 13 May 2024 11:40 (15 minutes)

1. OBJECTIVE/SCOPE
Geologic CO2 sequestration (GCS) has been considered as a promising engineering measure to reduce global greenhouse emission. Real-time monitoring of CO2 leakage is an essential aspect of large-scale GCS deployment. This work introduces a deep-learning-based algorithm using a hybrid neural network for detecting CO2 leakage based on bottom-hole pressure measurements.
2. METHODS, PROCEDURES, PROCESS
The hybrid neural network, called CNN-BiLSTM, leverages the strengths of convolutional neural network (CNN) and bidirectional long short-term memory (BiLSTM), in which CNN is used for spatial feature extraction and BiLSTM is applied for temporal dependency recognition. The CNN-BiLSTM enables us to build a spatial-temporal-based image-to-value regression model to learn the nonlinear mapping between high-dimensional input data (e.g., permeability, porosity, injection rate) and predicted bottom-hole pressure as output. The proposed workflow incorporates the generation of train-validation samples, the coupling process of training-validating, and the model evaluation. In this work, the diffusivity equation for pressure is solved within the CMG framework used to generate datasets under no-leakage conditions. A Bayesian optimization process is performed to optimize the network architecture, model hyperparameters, and the ratio of train to validation samples.
3. RESULTS, OBSERVATIONS, CONCLUSIONS
We test the CNN-BiLSTM performance on the bottom-hole pressure data collected from CO2 leakage simulations. Results show that the CNN-BiLSTM model can successfully detect CO2 leakage events by comparing the difference between the predicted (no leakage) and tested bottom-hole pressures. We further compare its superiority with CNN, LSTM, BiLSTM, and CNN-LSTM. Our proposed model achieves the highest accuracy with the same datasets. The CNN-BiLSTM outperforms other models owing to 1) its capacity to process image-based input, which could accurately capture input formation, especially cases with highly heterogeneous permeability; 2) its bidirectional ability to capture time-series dependency. Other models, like LSTM and BiLSTM, take value-based input, which is insufficient to describe the input information in highly heterogeneous cases. In contrast, CNN model suffers from capturing the temporal dependency features. Because of the bidirectional feature, CNN-BiLSTM shows higher accuracy, even 10% when applied to a small number of datasets, than the CNN-LSTM model.
4. NOVEL/ADDITIVE INFORMATION
We propose a hybrid neural network featuring Bayesian optimization for CO2 leakage detection. We demonstrate its applicability in terms of accuracy and robustness with other models. The proposed workflow can be implemented in commercial-scale GCS for real-time monitoring applications.

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