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"A Novel Application of Graph Neural Networks for Smart and Fast Track Digital Rock Physics"

Abstract

Digital rock physics (DRP) is an important part of the oil and gas industry. DRP refers to turning images and digitizes rock data into quantitative data. There are multiple possible paths for performing DRP. Pore Network Modeling (PNM) is a widely used method of turning digitize rock data into quantitative data. However, PNM is a time-consuming process, and it needs a large computation power. Research on Artificial Neural Network (ANN) has proven that ANNs can derive quantitative data from digitized rock data in recent years more time-efficiently and accurately. Several types of ANNs have been used for DPR, like Deep Neural Networks (DNN) and Convolutional Neural Networks (CNN). However, Graph Neural Networks (GNN) is a great type of Neural Network (NN) for graph-structured data. GNNs have proven useful due to their capability of message passing between nodes through edges (relationship). These edges allow nodes to communicate with each other and enhance the accuracy of the network. Our network is a mix of GNNs with Convolutional Neural Networks (CNN), which is better compatible with the dataset. The dataset includes sixty real micro-tomography 3D images. These images are used to generate 17,700 pseudo-3D samples using mixing methods. Pore network modeling, morphological properties, hydraulic properties, electrical properties, and mechanical properties for all real and pseudo samples were calculated. Several architectures of our CNN and GNN mix network were tested. These tests were done on two different normalizations of Rabbani's dataset, normalized and log normalized. The two datasets were used for training and testing for several networks. The R2 for GNN 1 architecture are 0.92 and 0.90 for normalized and log normalized dataset. GNN 1 architecture shows only a slight improvement to DeePore's R2, which is 0.89. GNN 2 architecture results in R2 of 0.91 and 0.95 for normalized and log normalized data. GNN 2 with normalized data used for training results in a slight improvement of the network. However, GNN 2 with log normalized data creates a significant improvement to the accuracy of the testing results. GNN 3 architecture results in R2 of 0.92 and 0.94 for normalized and log normalized dataset. GNN 2 and GNN 3 trained with log normalized data result in the best R2 than all other GNNs and DeePore CNN. However, GNN 3 architecture is twice as large as GNN 2. The huge number of parameters causes training of GNN 3 to be much longer than GNN 2; For this reason, GNN 2 trained with log normalized data results in the best overall accuracy.

Date:

Friday, Feb 12th, 2021

Time:

Starts @ 1:30PM

Zoom Meeting Details:

HYPERLINK

Meeting ID: 979 1721 5978

Password: 431544

Committee Chair:

Assistant Professor Amirmasoud Kalantari