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Prediction of Subsurface Fluid Flow via Physics Informed Neural Networks

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Geoenergies such as underground gas storage and energy storage, geothermal energy and geologic carbon storage are key technologies on the way to the foreseeable energy transition. The reservoir characterization in these projects remains challenging since predictive modeling approaches face limitations in identifying the spatial distribution of distinct lithologies and their hydro-mechanical properties from downwell testing procedures. Pumping tests are usually carried out to infer permeability, but offer only few observation points in space and require large extrapolation through inversion. The application of Physics Informed Neural Networks (PINN) offers a promising solution which can seamlessly incorporate field data, while enforcing the accordance with physical laws in the domain of study. This concept is implemented via two distinct loss terms for both the physical constraints and for the observational data in the loss function of an Artificial Neural Network (ANN). The physics-informed loss term contains a mass balance equation consisting of a storage and a diffusion component. The process is considered to be purely hydraulic and Darcy flow is assumed. The observational loss term compares the output of the ANN to a set of training data. This set consists of the system's initial fluid pressure, as well as of a fluid pressure time series at the domain boundaries and at the borehole location. Preliminary results suggest that our PINN model is able to forecast the spatiotemporal fluid pressure distribution in a 2D domain for a variety of pumping test schemes. In this way, we give a first impression of the opportunities that PINN applications offer in the field of reservoir modeling.