GEOGULF2021
AUSTIN
October 27–29, 2021

Machine Learning Assisted Production History Matching while Retaining Geological Heterogeneity

H. Jo and M. J. Pyrcz

ABSTRACT

Correct characterization and reproduction of hierarchical geological heterogeneity are critical to reservoir forecasting. Outcrop, shallow seismic, mature field, and experimental flume studies have developed excellent architectural hierarchies that have informed reservoir modeling through modern rules-based and multiple-point geostatistical simulation. However, production history matching remains an unsolved problem with current workflow removing critical heterogeneities from the reservoir realizations resulting in low accuracy future production forecasts. Moreover, significant computation time in the history matching process, especially with high-dimensional reservoir parameters, impedes rapid and reliable decision-making in reservoir management.

We propose a novel history matching workflow that can effectively shorten the computational time in history matching while preserving the impact of geological, architectural hierarchies by using conditional generative adversarial networks (CGAN). First, we generate multiple reservoir realizations from ultra-realistic rules-based modeling and then run reservoir flow simulations to calculate their responses (e.g., well oil production rate and bottom hole pressure). Then, we train a GAN that is conditioned to the training models and their associated dynamic responses. The successfully trained conditional GAN enables exploring the possible range of reservoir models with any given well responses. Therefore, after training, we can easily input the observations from the field to the GAN to generate the ensemble of possible reservoir realizations without any further reservoir flow simulation runs.

Compared to conventional history matching methods, the proposed method only requires 50% fewer reservoir simulation runs, resulting in accurate forecasts and preservation of realistic geological heterogeneity in the updated reservoir models.

Jo, H., and M. J. Pyrcz, 2021, Machine learning assisted production history matching while retaining geological heterogeneity: GeoGulf Transactions, v. 71, p. 423.

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