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Production Optimization under Geological Uncertainty Using Distance-Based Clustering

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Abstract : It is important to figure out reservoir properties for better production management. Due to the limited information, there are geological uncertainties on very heterogeneous or channel reservoir. One of the solutions is to generate multiple equi-probable realizations using geostatistical methods. However, some models have wrong properties, which need to be excluded for simulation efficiency and reliability. We propose a novel method of model selection scheme, based on distance-based clustering for reliable application of production optimization algorithm. Distance is defined as a degree of dissimilarity between the data. We calculate Hausdorff distance to classify the models based on their similarity. Hausdorff distance is useful for shape matching of the reservoir models. We use multi-dimensional scaling (MDS) to describe the models on two dimensional space and group them by K-means clustering. Rather than simulating all models, we choose one representative model from each cluster and find out the best model, which has the similar production rates with the true values. From the process, we can select good reservoir models near the best model with high confidence. We make 100 channel reservoir models using single normal equation simulation (SNESIM). Since oil and gas prefer to flow through the sand facies, it is critical to characterize pattern and connectivity of the channels in the reservoir. After calculating Hausdorff distances and projecting the models by MDS, we can see that the models assemble depending on their channel patterns. These channel distributions affect operation controls of each production well so that the model selection scheme improves management optimization process. We use one of useful global search algorithms, particle swarm optimization (PSO), for our production optimization. PSO is good to find global optimum of objective function, but it takes too much time due to its usage of many particles and iterations. In addition, if we use multiple reservoir models, the simulation time for PSO will be soared. By using the proposed method, we can select good and reliable models that already matches production data. Considering geological uncertainty of the reservoir, we can get well-optimized production controls for maximum net present value. The proposed method shows one of novel solutions to select good cases among the various probabilities. The model selection schemes can be applied to not only production optimization but also history matching or other ensemble-based methods for efficient simulations.

Keywords : distance-based clustering, geological uncertainty, particle swarm optimization (PSO), production optimization
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