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Geostatistics-based Decision-making in Reservoir Engineering

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SUMMARY

In this paper, we propose a workflow where we use geostatistical simulations to estimate the probability of all the possible outcomes of a set of business decisions, such as drilling a new well or acquiring new data. These probabilities are then directly used in a decision tree in order to determine the optimal decision to minimize the costs and maximize the profits. Geostatistical algorithms provide a set of tools to mimic the spatial distribution of rock and fluid properties in the reservoir, in different geological scenarios and under different assumptions. The variability of these geostatistical realizations can be used to quantify the model uncertainty. This uncertainty can be represented using probability distributions. On the other hand, decision theory is a discipline that aims to provide tools to identify the values and uncertainties of a set of decisions and the resulting optimal choice. Business decisions in petroleum industry represent a good example of applications of decision theory since each decision generally has more than one possible uncertain outcome with different probabilities.

In order to make predictions of the future behavior of a reservoir system, we generally build mathematical-physical models with the aim of providing a realistic description of the reservoir, estimating reservoir properties and predicting property changes and production forecasts. Model predictions are then used to make decisions, however these models are generally uncertain because of the limited amount of measurements, the quality of the measured data, the approximations in the physical models, and the natural variability and heterogeneity in the system. Probability random fields and/or multiple geostatistical realizations are generally used to represent the model uncertainty; however, we generally tend to summarize the information coming from geostatistics in a deterministic information, such as the mean of the rock property, and we tend underestimate the uncertainty in the final predictions.

In this paper, we propose a workflow where we use geostatistical simulations to estimate the probability of all the possible outcomes of a set of business decisions, such as drilling a new well or acquiring new data. These probabilities are then directly used in a decision tree in order to determine the optimal decision to minimize the costs and maximize the profits. Geostatistical algorithms (see Goovaerts, 1997 and Deutsch, 2002) provide a set of tools to mimic the spatial distribution of rock and fluid properties in the reservoir, in different geological scenarios and under different assumptions. The variability of these geostatistical realizations can be used to quantify the model uncertainty. This uncertainty can be represented using probability distributions. On the other hand, decision theory is a discipline that aims to provide tools to identify the values and uncertainties of a set of decisions and the resulting optimal choice. Business decisions in petroleum industry represent a good example of applications of decision theory since each decision generally has more than one possible uncertain outcome with different probabilities (Caers, 2010). In this example, we show how to use geostatistical simulations to infer probabilities of different outcomes and use these probabilities to solve a decision tree.

Figure 1 Example of decision tree solved based on results of geostatistical simulations.

References

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