Application of Multi-Objective Genetic Algorithm for Improving Automated Geosteering Performance

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Abstract

Geosteering is the practice of solving for the stratigraphic position of a wellbore while drilling by matching features of an LWD log (such as natural gamma ray) to nearby reference logs. Traditionally this is done manually by a geologist, however several approaches have been proposed for algorithmically automating the process (Gee et al. 2019, Maus et al. 2020, Mitkus et al. 2022). These methods are sensitive to input parameters that impact the model in complex ways and optimizing these parameters by hand is subjective and impractical. This optimization problem can be solved algorithmically using a combination of synthetic data to establish ground truth and multi-objective optimization using a genetic algorithm. To remove subjectivity in assessing geosteering solutions, we created 1440 synthetic geosteering trials with geologically realistic LWD logs and a known true solution split 80/20 into training and test data. The optimization's objective function averaged two metrics across the synthetic trials to compare solutions: "mean distance" a measure of how far apart the automated and true solution are stratigraphically, and "misfit ratio" a measure of how the gamma mapping of the automated solution compares to the true solution. We selected NSGA-II (Deb et al. 2002), a multi-objective genetic algorithm, to perform the optimization of the geosteering algorithm input parameters subject to these objective functions. The optimization resulted in a set of Pareto optimal parameter configurations that were validated using wells in the test set to ensure configuration robustness and compared to the original human-selected default configuration. NSGA-II output 14 Pareto optimal parameter configurations with different tradeoffs between mean distance and misfit ratio. One optimal set showed improved performance over the human-selected configuration, with a 40% decrease in mean distance and a 7% decrease in misfit ratio on the test set, demonstrating how the proposed method can be used to improve automated geosteering performance. NSGA-II is a widely used algorithm in many fields, however the combination of its multi-objective optimization and true solutions from synthetic geosteering trials is novel and allows for greatly increased performance of automated geosteering algorithms. Additionally, because NSGA-II outputs more than one optimal solution, domain knowledge and intuition can be applied in the selection of the most useful parameter set.