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Automated Geosteering with Fault Detection and Multi-Solution Tracking

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Abstract

Development of autonomous drilling technologies requires the automated analysis and interpretation of Logging While Drilling (LWD) data to optimally land the well in the target formation and keep it in the pay zone. This paper presents a fully automated geosteering algorithm, which includes advanced LWD filtering, fault detection, correlation, tracking of multiple interpretations with associated probabilities and visualization using novel stratigraphic misfit heatmaps.

Traditional geosteering uses manual stretch, compress and match techniques to correlate measurements along the subject wellbore against corresponding reference type logs. This results in a crude representation of strata by linear sections with offsets at fault locations. Instead of automating this manual process, we instead determine the possible interpretations as solutions of a geophysical inverse problem in which the total misfit between the subject and reference data is minimized. Interpretations are parameterized as discontinuous splines to accurately follow curved strata interjected by fault offsets. To account for ambiguities, multiple possible interpretations are continuously tracked in real time and assigned probabilities based on the misfit between the latest measurements and the reference data. Unrealistic solutions are suppressed by penalizing strong curvature and large fault offsets. Viable interpretations are simultaneously visualized in real time as paths on a novel stratigraphic misfit heat map, where they may be corroborated against valleys of minimal misfit between the subject and reference data. The user can guide the interpretation by setting control points on the heat map which the automated solutions must respect.

The algorithm has been validated using wells from different regions across North America for which previous manual geosteering interpretations are available. The automated spline interpretations represent the actual curved strata more accurately than manual interpretations. Operationally, the automated interpretations can be provided within minutes compared to typical manual turn-around times of hours. Automation leads to more consistent and repeatable results, removing the subjectivity of manual interpretations.