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Geophysical Methods and Machine Learning Algorithms for Stuck Pipe Prediction and Avoidance

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Abstract : Cost reduction and drilling optimization is the goal of many drilling operators. Historically, stuck pipe incidents were a major segment of non-productive time (NPT) associated costs. Traditionally, stuck pipe problems are part of the operations and solved post-sticking. However, the real key to savings and success is in predicting the stuck pipe incidents and avoiding the conditions leading to its occurrences. Previous attempts in stuck-pipe predictions have neglected the local geology of the problem. The proposed predictive tool utilizes geophysical data processing techniques and Machine Learning (ML) algorithms to predict drilling activities events in real-time using surface drilling data with minimum computational power. The method combines two types of analysis: (1) real-time prediction, and (2) cause analysis. Real-time prediction aggregates the input data, including historical drilling surface data, geological formation tops, and petrophysical data, from wells within the same field. The input data are then flattened per the geological formation and stacked per stuck-pipe incidents. The algorithm uses two physical methods (stacking and flattening) to filter any noise in the signature and create a robust pre-determined pilot that adheres to the local geology. Once the drilling operation starts, the Wellsite Information Transfer Standard Markup Language (WITSML) live surface data are fed into a matrix and aggregated in a similar frequency as the pre-determined signature. Then, the matrix is correlated with the pre-determined stuck-pipe signature for this field, in real-time. The correlation used is a machine learning Correlation-based Feature Selection (CFS) algorithm, which selects relevant features from the class and identifying redundant features. The correlation output is interpreted as a probability curve of stuck pipe incidents prediction in real-time. Once this probability passes a fixed-threshold defined by the user, the other component, cause analysis, alerts the user of the expected incident based on set pre-determined signatures. A set of recommendations will be provided to reduce the associated risk. The validation process involved feeding of historical drilling data as live-stream, mimicking actual drilling conditions, of an onshore oil field. Pre-determined signatures were created for three problematic geological formations in this field prior. Three wells were processed as case studies, and the stuck-pipe incidents were predicted successfully, with an accuracy of 76%. This accuracy of detection could have resulted in around 50% reduction in NPT, equivalent to 9% cost saving in comparison with offset wells. The prediction of stuck pipe problem requires a method to capture geological, geophysical and drilling data, and recognize the indicators of this issue at a field and geological formation level. This paper illustrates the efficiency and the robustness of the proposed cross-disciplinary approach in its ability to produce such signatures and predicting this NPT event.

Keywords : drilling optimization, hazard prediction, machine learning, stuck pipe
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