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Hybrid Data-Driven Drilling Rate of Penetration Optimization Scheme Guided by Geological Formation and Historical Data

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Abstract : Optimizing the drilling process for cost and efficiency requires the optimization of the rate of penetration (ROP). ROP is the measurement of the speed at which the wellbore is created, in units of feet per hour. It is the primary indicator of measuring drilling efficiency. Maximization of the ROP can indicate fast and cost-efficient drilling operations; however, high ROPs may induce unintended events, which may lead to nonproductive time (NPT) and higher net costs. The proposed ROP optimization solution is a hybrid, data-driven system that aims to improve the drilling process, maximize the ROP, and minimize NPT. The system consists of two phases: (1) utilizing existing geological and drilling data to train the model prior, and (2) real-time adjustments of the controllable dynamic drilling parameters [weight on bit (WOB), rotary speed (RPM), and pump flow rate (GPM)] that direct influence on the ROP. During the first phase of the system, geological and historical drilling data are aggregated. After, the top-rated wells, as a function of high instance ROP, are distinguished. Those wells are filtered based on NPT incidents, and a cross-plot is generated for the controllable dynamic drilling parameters per ROP value. Subsequently, the parameter values (WOB, GPM, RPM) are calculated as a conditioned mean based on physical distance, following Inverse Distance Weighting (IDW) interpolation methodology. The first phase is concluded by producing a model of drilling best practices from the offset wells, prioritizing the optimum ROP value. This phase is performed before the commencing of drilling. Starting with the model produced in phase one, the second phase runs an automated drill-off test, delivering live adjustments in real-time. Those adjustments are made by directing the driller to deviate two of the controllable parameters (WOB and RPM) by a small percentage (0-5%), following the Constrained Random Search (CRS) methodology. These minor incremental variations will reveal new drilling conditions, not explored before through offset wells. The data is then consolidated into a heat-map, as a function of ROP. A more optimum ROP performance is identified through the heat-map and amended in the model. The validation process involved the selection of a planned well in an onshore oil field with hundreds of offset wells. The first phase model was built by utilizing the data points from the top-performing historical wells (20 wells). The model allows drillers to enhance decision-making by leveraging existing data and blending it with live data in real-time. An empirical relationship between controllable dynamic parameters and ROP was derived using Artificial Neural Networks (ANN). The adjustments resulted in improved ROP efficiency by over 20%, translating to at least 10% saving in drilling costs. The novelty of the proposed system lays is its ability to integrate historical data, calibrate based geological formations, and run real-time global optimization through CRS. Those factors position the system to work for any newly drilled well in a developing field event.

Keywords : drilling optimization, geological formations, machine learning, rate of penetration
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