Optimization of ROP with Drilling Parameters and Petrophysical Data Using Machine Learning Approach

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Abstract:

Rate of Penetration (ROP) is an important parameter during oil and gas drilling which influences drilling performance. Methods to optimize ROP involve selecting optimum drilling variables prior to a run or real-time optimization of ROP by varying Weight on Bit (WOB), Revolutions per Minute (RPM), Flowrate, and Total Flow Area (TFA).

Most of the methods for optimizing ROP using machine learning techniques involve only the drilling parameters without consideration of the formation. The method presented in this paper utilizes petrophysical data in addition to drilling data for ROP optimization. The data collected was cleaned to remove missing data and other data inconsistencies. Data pre-processing measures which included data scaling, feature correlation, feature selection, etc. were applied prior to data modeling.

The 17.5in and 12.25in well sections were analyzed and the formation was divided into clusters based on the formation evaluation data using an unsupervised algorithm (K-means). Five machine learning algorithms which include Linear Regression, Random Forest, Support Vector Machine, K Nearest Neighbors (KNN), and Xtreme Gradient Boosting in addition to sensitivity analysis were trained and tested on data from 10 wells to optimize the drilling parameters to optimize the ROP. The best model (Random Forest) which accurately predicts ROP for each formation layer was selected based on the least Root Mean Square Error (RMSE).

The analysis of our models show that the best model which optimizes ROP is that which incorporates both the formation and drilling data, as this had the highest model accuracy and lower RMSE when compared to the model which utilized only drilling data.

Authors' Biography:

Oyindamola Obisesan holds a bachelor's degree in Petroleum Engineering from the Afe Babalola University Ado-Ekiti, he also holds a dual master's degree in Petroleum Engineering and Data Science & Analytics from the University of Oklahoma.

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a graduate research assistant at the Integrated Core Characterization Center (IC3), his research has focused on tortuosity, enhanced oil recovery, rock-fluid interactions in shales and the application of machine learning to petroleum engineering. He is a two-time Society of Petrophysicists and Well Log Analysts (SPWLA) International Student Paper Contest first-place winner and a multiple award winner. He obtained his BSc. in Petroleum Engineering (First Class Honors) from the University of Lagos, Nigeria.

About Research Topic:

Rate of Penetration (ROP) is a singular most important parameter during the drilling of an oil and gas well. Drilling days per thousand feet (DDPTF) is a measure of drilling performance. The DDPTF is highly influenced by the ROP which is why the ROP is a very important drilling variable. The aim of a drilling operation is to reduce drilling time i.e., maximize ROP and reduce drilling risk. There are approaches to optimize ROP, optimum drilling variables section prior to a run and real time optimization of ROP by varying Weight on Bit (WOB), Revolution Per Minute (RPM), Torque.

There have been efforts (theoretical and experimental) to model ROP as a mathematical function of some variables, but this is not a trivial problem as it is a highly non-linear problem. The most common traditional ROP model (physics-based model) is the Bourgoyne and Young equation based on analytical equations. The physics model attempts to understand the physical nature of well drilling, describing the drilling activities with analytical equations. This work aims to use machine learning algorithms to understand the relationship between these parameters and use this understanding to optimize the ROP.

The plan of this work is however to predict and optimize the ROP and reduce drilling time by adjusting surface drilling parameters such as WOB, torque, surface RPM, flowrate, MSE, HSI. The importance to this is to understand the changes in ROP based on the drilling parameters. The objective is to access how some important drilling variables (RPM, WOB, flowrates) affects ROP. In this way, the ROP can be increased by tweaking the other drilling parameters. The findings from this work can be extended to drilling systems and software that would suggest drilling parameters in real-time during drilling operations.

About Institution:

The University of Oklahoma is a public research university in Norman, Oklahoma. The university's Petroleum Engineering program is among the top 5 in the nation. Mewbourne College of Petroleum and Geological Engineering which is home to the petroleum engineering program conducts leading research in Petrophysics, Drilling, Production Engineering and also Unconventional resources. The college boasts of faculty members of outstanding reputation within the Society of Petroleum Engineers (SPE), SPWLA and other professional bodies in the industry.

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