Visualization Informed Drilling: Optimization and Automation On-The-Fly at the Bit*

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Abstract

Visualization and interpretation techniques play a key role in integrating downhole data and processes. Advanced technologies, like electromagnetic and wired telemetry systems, have enabled us to obtain large volumes of data on a real-time basis while the drilling activity is still in progress. The next step change in drilling programs would be to perform a real-time optimization and automation of the existing well designs on-the-fly at the bit based on energy-based intelligent systems. Injecting life into the well-design process, itself, will provide amazing power. During well design, monitoring, or drilling, if the well plan is made interactive, it will provide a tremendous opportunity to optimize and make proper decisions to drill ahead as well as automate the operation. This study presents a real-time optimization technique for rate of penetration with energy-based models, with the goal of reducing well costs. Interactions with nearby wells have also been incorporated to update the well design. Based on the place and position of the bit, the updated data has been used to modify the proposed well design on the fly. A ‘RoboCube’ visualization technique has been proposed to perform optimization of drilling parameters. Two modes of implementation have been presented, namely ‘DecisionSCAN’ and ‘SpaceSCAN.’

Introduction

‘DecisionSCAN’ serves as the single well mode, wherein the real-time data from the well being drilled is used for optimization to display the optimum envelope cube. This method provides a better optimization environment by providing for optimization and tracking in a single 3-D view, thus significantly reducing time and effort for monitoring and control. ‘SpaceSCAN’ provides the multiple wells’ scan mode to scan the nearby wells and obtain additional desired data for analyzing the existing well and fracture positions for collisions. The proposed method has the ability to perform uncertainty calculations and suggest forward predictions and alarms. This is going to be particularly important with the increasing activities in shale plays, which require a large number of wells and fractures to economically drain the reservoirs.

Discussion

The existing optimization methods are carried out for certain depths with constant weight-on-bit, RPM and, flow rate to achieve the maximum rate of penetration, with minimum mechanical specific energy or well cost. However, certain unalterable parameters, such as formation heterogeneities, formation strength, etc., and alterable operating parameters, such as weight-on-bit, downhole torque, downhole density, etc., change with depth. Hence, the optimization is no longer static and becomes a dynamic function of depth. These conditions result in constantly varying constraints and, thereby, constantly varying optimized operating parameters to maximize the rate of penetration or minimize specific energy or well cost.

The proposed visualization technique will demonstrate a proof-of-concept for a simple optimization coupling with alterable variables, such as weight on bit, rotational speed, and flow rate and an unalterable variable, like the formation strength. The method will provide the option of real-time, on-demand data analysis with either stored and catalogued data or real-time data. The data set is cleaned with simple methods, like limit violation and first/second derivative violation, and the inputs are displayed in the visualization cube on the left side of the wellbore. The data is then used to calculate the optimum values, which are displayed on the right side of the wellbore. The actual value is displayed as a red dot, while the optimum value is displayed as a green dot. This technique allows a visual representation to be created in the form of an optimum cube over the well path and will be animated as the well is drilled in real time. It also provides the option to view optimum cubes along the wellbore in which the decision and optimum parameters are displayed over the actual well plan. This visualization technique has further been demonstrated using Figure 1 for the 'DecisionSCAN' mode and Figure 2 for the 'SpaceSCAN' mode.

Summary

This proposed visualization and interpretation method has the ability to provide improved control of the drilling parameters, predict drilling-ahead problems, and minimize non-productive time. The implementation of this technique will provide better hole quality and well placement, as well as reduce the cost per foot of drilling. The method has the ability to perform optimization under both the scenarios, for a single well with real-time data or for multiple wells having both historical as well as real-time data. The optimization can be carried out either as a static objective function with static boundary conditions or as moving objective functions having moving boundary conditions. The optimized variables obtained thereof can further be used either to drill further or to automate the system at the surface or at the bit.

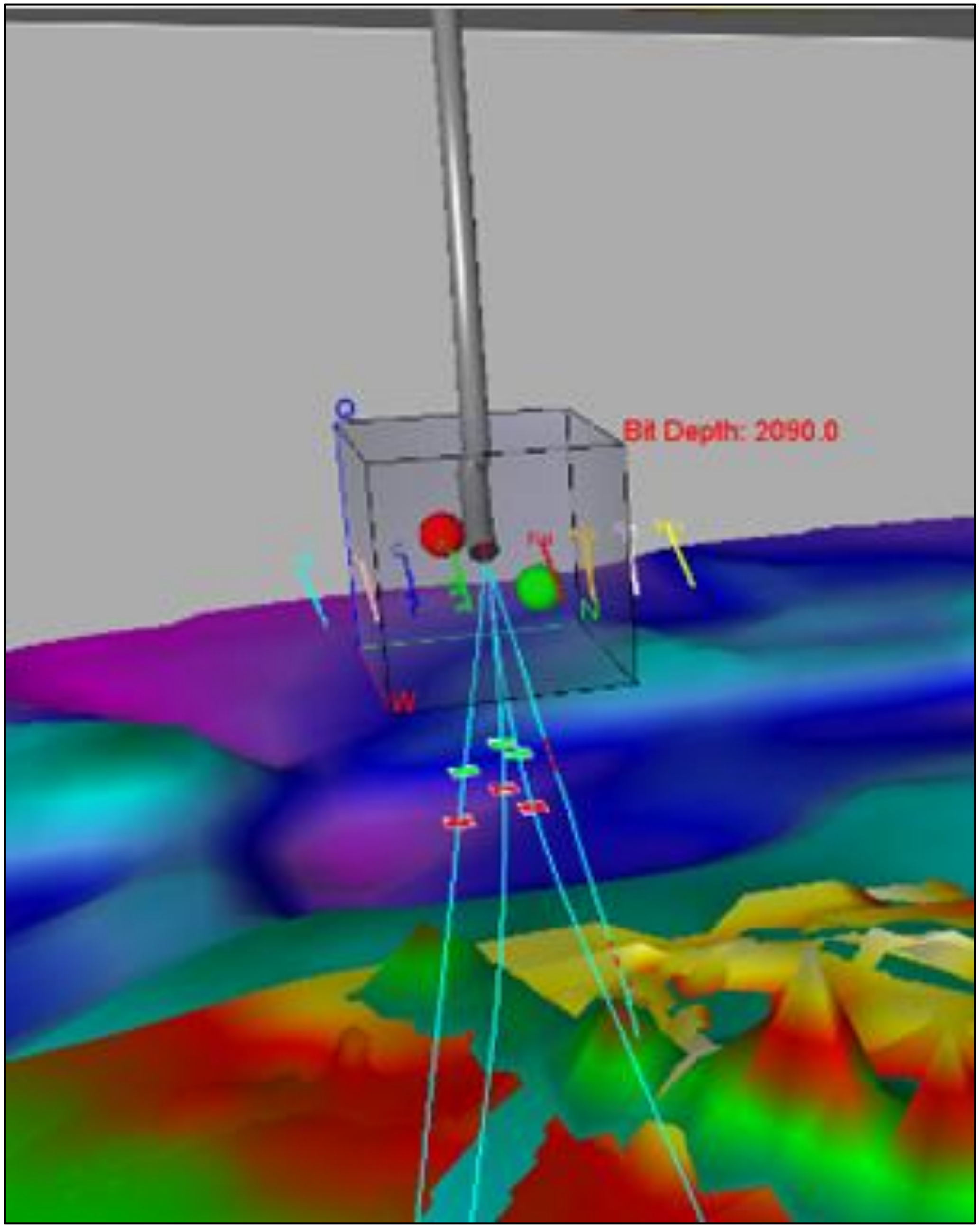

Figure 1. RoboCube DecisionSCAN.

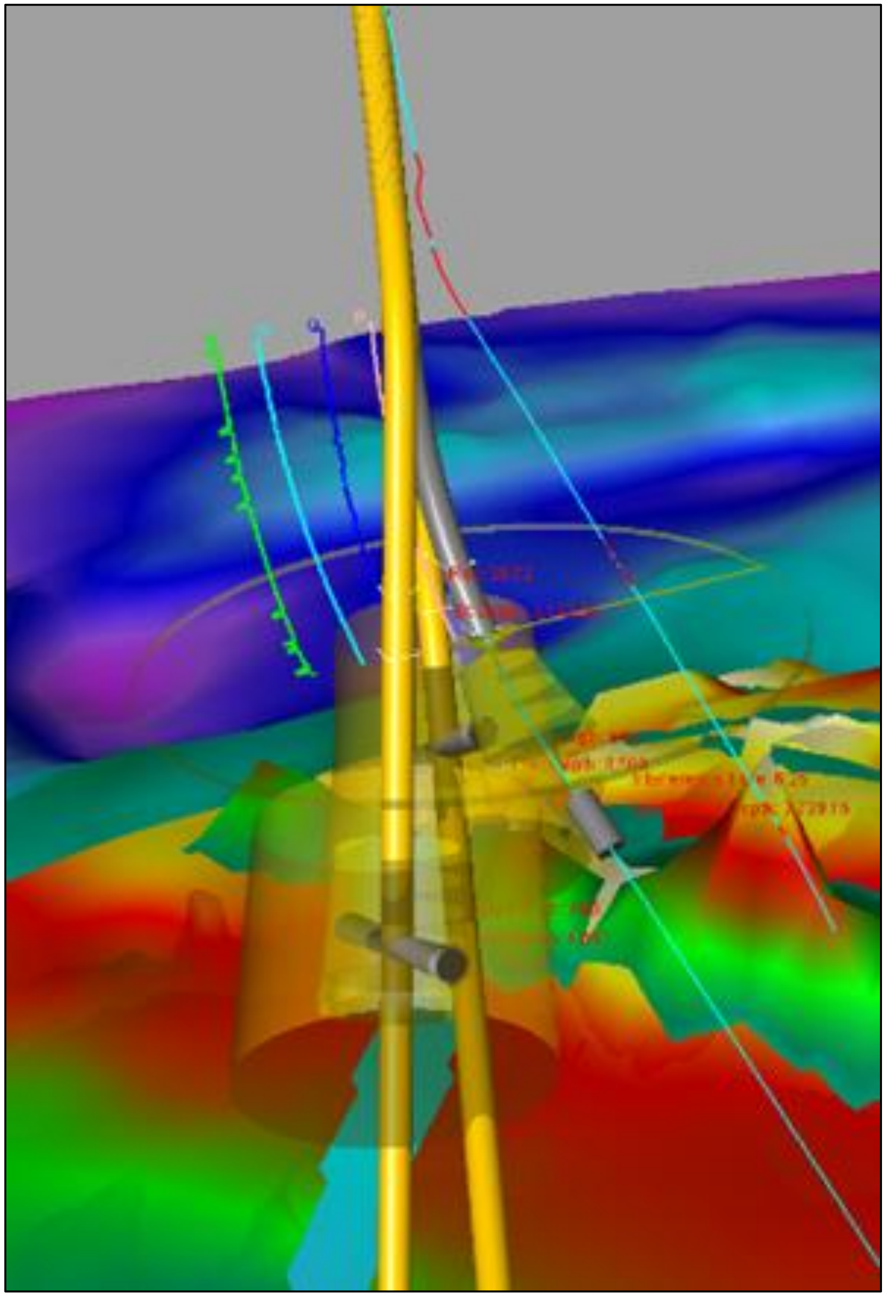

Figure 2. RoboCube SpaceSCAN