

Applied Geoscience Conference

Transforming Well Path Planning: You can plan the most productive well and drill it, too

Houston Geological Society Subsurface Intelligence and Analytics Conference

March 5-6, 2019 The Woodlands, TX

David Cotrell, Tobias Hoeink, & Sachin Ghorpade BHGE Digital, Reservoir & Wells

 $1^{\mbox{st}}$ Subsurface Intelligence and Analytics Conference - 2019

AUTOMATED WELL PLANNING

"The goal here is to suggest the best well trajectory (in terms of maximum pay zone contact) based on limited parameters (e.g. well head location and target zones).

The expected output would be a well trajectory that maximizes the contact between the well and target location, typically defined by property cutoff (e.g., ϕ > 0.2 & K > 5mD, etc.), and is drillable."

Full Wellbore / Wellpad Planning

Define (or let computer assists in identifying):

- Well head location
- Reservoir entry points
- Target zone(s)



For one wellbore or the entire pad at once.



Motivation

- Speed up the well planning process by allowing the computer to pick the optimal wellbore path for a given field and pay zone
- Ability to optimize wellbore path based on a user defined metric (e.g., porosity)
- Ability to take into account wellbore stability considerations, where the ability to safely drill a well depends on the full stress state, wellbore orientation, and material properties
- Ability to take into account drill-ability constraints such as deviation limitations (i.e., build rate or bend curvature), and nearness of existing wells
- Make sure that the planned well does not come close to any other assets in the field (e.g., other wells, no-go zones, etc.)

Introduction

Today, well trajectories are planned by manual considerations, whereby the truly optimal well is likely not identified because not all possible wells can be evaluated by a human in reasonable time.

- Well planning is a very important first step of oil and gas recovery:
 - Involves many different disciplines (geoscientists, drilling engineers, asset managers, etc.)
 - Involves iterating back-and-forth between the various disciplines
 - Can take on the order of days to weeks (or longer) depending on the complexity of the field of interest (e.g., offshore wells)

Formulation: Fully 3D Solution

• Objective

- Identify well trajectory with maximum pay zone contact (e.g., $\phi > 0.2 \& K > 5 mD$)
- Constraints
 - Limited input (e.g., well head location and target zones)
 - Drill-ability (e.g., well deviation, build-rate, dog-leg severity)
 - Wellbore stability (mud weight window based on geomechanical analysis, stress state, wellbore orientation, material properties)
 - Collision avoidance
 - No intersecting wellbores
 - Wellbores do not pass through any no-go zones

Optimization algorithm

- Monte Carlo method
- Achieves near ideal linear speedup
- Well segments are scored: length*porosity
 - Summed over total well length, i.e., all well segments

Problem Setup

Fully Three-Dimensional Solution

• Horizontal well investigated

- Wells are constrained to not vary in vertical direction within the pay zone
- Objective function used is porosity with a threshold of 0.2 (i.e., "good" regions of the field have a value above 0.2)
- Build-rate is between -3 and 3 degrees per 100 feet (i.e., long-radius well)
- Wellbore stability has been taken into account, where initially we have only considered absolute stability, but moving forward will allow for some amount of breakout to occur and still flag the wellbore as stable (e.g., 30 degree for horizontal wells)
- Critical mud weight upper limit is taken to be 15 ppg, i.e., maximum allowed in the field
- Fixed and variable landing zone in the pay zone

Borehole Stability: Horizontal well



Subsurface Porosity Map: Planer Projection



Results: Fixed Landing Zone



Results: Variable Landing Zone



Final Results: Fixed and Variable Landing Zone

Best and worst stable and unstable wells, where stable wells are shown as solid lines and unstable wells are shown as dashed lines.





3D Final Results: Fixed Landing Zone





CRS: Minna / Nigeria Mid Belt *EPSG::26392*

3D Final Results: Fixed Landing Zone



Conclusions

- The current method poses the optimal well path problem in such a way that takes advantage of today's significant computing power allowing the well planning process to be completed in days instead of weeks or months
- The current approach is highly parallelizable, and obtains the hard to realize ideal linear scaling with-respect-to the number of processors available
- The optimal well path is significantly affected by drilling equipment (e.g., allowable build rate) and subsurface properties (i.e., wellbore stability)
- The current approach is guaranteed to either find an optimal well path that is drillable, stable, and hits the most "good" regions in the pay zone while satisfying the two afore mentioned constraints, or inform the user that their mud weight upper limit is to low for this field and needs to be revised

The Future

The workflow described and shown in this presentation is part of a much broader workflow that delivers **full service acreage planning**; finds the optimal number of wells, their placement, and their stimulation treatments for a given reservoir.

• Required workflows

- Ability to find the optimal wellbore path for each well in a reservoir
- Ability to find the optimal number of stages and clusters per stage for a wellbore
- Ability to find the optimal number of wells to drill in a reservoir
- Ability to perform low-order production forecasting for the entire reservoir taking into account all the wells

Constrained optimization will be used in this workflow to maximize production (over some amount of time) for use in picking an optimal reservoir configuration, i.e., number of wells, their placement and stimulation treatments.

^{1&}lt;sup>st</sup> Subsurface Intelligence and Analytics Conference - 2019

