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AAPG Decision Based Integrated Reservoir Modeling GTW
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Posters

GEOSTEERING UNDER GEOLOGICAL UNCERTAINTY

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ABSTRACT

This work presents a novel, ensemble-based workflow for well placement under geological uncertainty. The goal is to make geosteering decisions that adapt to incoming data while accounting for multiple possible geological scenarios within a model ensemble. Traditional geosteering uses a single "base case" geomodel that engineers update during drilling. That approach assumes one model can represent reality, even though geological uncertainty always exists. We show that by using an ensemble based approach to geosteering we can improve the expected value of the well if our ensemble adequately describes the uncertainty.

Our proposed workflow replaces the single model with an ensemble of geomodels, which captures structural and stratigraphic variability in a finite set of geological models. The ensemble can therefore provide a basis for evaluating drilling decisions at key points during operations, under uncertainty. In our workflow, we treat each model as one hypothesis about the subsurface, each with its own probability, which the workflow uses to estimate the best expected well pathway. This turns geosteering into a probabilistic optimisation problem rather than a deterministic correction process of a single model.

We demonstrate the ease of implementing our approach by embedding it within the integrated commercial geomodelling platform, leveraging its ensemble geomodelling tools alongside our decision-tree-based approach to update model probabilities. The algorithm, written in Python, initially defines a set of well paths that are viable with a set of decision nodes, where the algorithm will decide upon the optimal path.

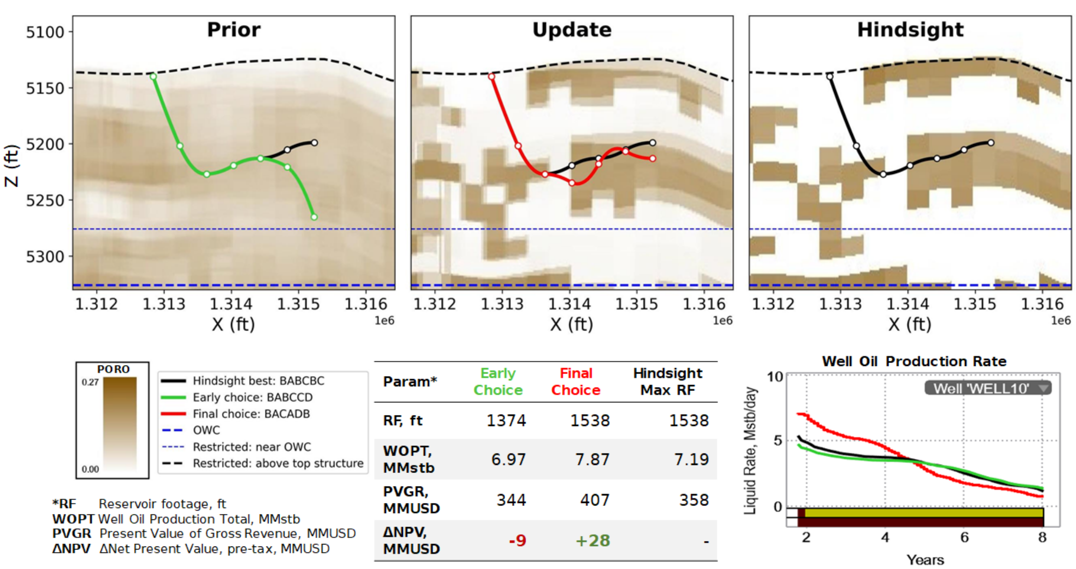
For each well path, we evaluate the expected reservoir footage (RF) in the well based on the facies it intersects. Thus, the best well is the route that intersects the most highly permeable sand on average. At each decision node, it updates the model probabilities using logging-while-drilling (LWD) and measurement-while-drilling (MWD) data by comparing synthetic logs generated for each model in the ensemble with measured data. A Boltzmann transform converts log-mismatches to likelihoods, and renormalisation updates the model probabilities. The updated probabilities are then used to estimate an updated expected reservoir footage, which will adjust the next steering choice based on the options available to that node. The process repeats at each decision node until the target depth/length is reached.

We demonstrated the workflow using a semi-synthetic Watt field benchmark that captures uncertainty in structure, facies, petrophysical cut-offs, and relative permeability [1]. The algorithm selected near-optimal well paths across tested scenarios, increased reservoir contact, and improved production and net present value (NPV) compared to traditional single-model steering. These results, shown in Figure 1 below, confirm that ensemble-based steering can deliver measurable economic and operational benefits.

A sensitivity study tested the workflow’s robustness and identified four key insights:

1. Ensemble diversity is essential. Narrow ensembles limit adaptability and can bias steering.
2. Reservoir footage is not always the best objective function. Production-based metrics provide a more realistic optimisation target in many cases.
3. Mismatch metrics matter for the approach's effectiveness. Localised dynamic time warping (DTW) performs better than Euclidean distance for log comparison.
4. Decision-tree settings, such as node spacing and steering bounds, have limited early impact on geosteering choice when uncertainty dominates.

Our findings show how ensemble design and objective selection influence steering quality. They also highlight where future work should focus: adaptive decision trees, smarter ensemble updates, and improved objective functions tied to economic outcomes. Our proof of concept system shows how the proposed workflow can be easily implemented in a commercial software for use on real projects.



Param*	Early Choice	Final Choice	Hindsight Max RF
RF, ft	1374	1538	1538
WOPT, MMstb	6.97	7.87	7.19
PVGR, MMUSD	344	407	358
ΔNPV, MMUSD	-9	+28	-

Figure 1. Well trajectories planned without accounting for uncertainty (Prior, in green), geosteered under uncertainty (Update, in red), and benchmarked against the hindsight (in black)

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References

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