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Live Earth Modeling Enabled by ML Workflows and Grid-Less Multi-Scale Model

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Abstract

Live Earth Model Building Challenges

The Reservoir Modeling is an indispensable part of Field Development Planning and the foundation building block which helps to unveil the detailed insights of the target reservoir's characteristics. In the process of building a sub-surface reservoir model, the Geo-modelers integrate all sort of data from various domains such Well interpretation, seismic attributes, seismic interpretation, rock-physics data etc.

However, the inherent challenge of conventional grid-based model is that at the first place the modeler needs to lock the resolution with the grid scale. Due to locking the grid resolution, the log and seismic data needs to be upscaled in that resolution, losing the original resolution and information in the gridded model. The upscaling process of a grid-based model also minimizes the impact of Ai/ML workflows by applying the algorithms on average properties instead of original resolution. Some of the key challenges are mentioned in the grid-based modeling approach.

Trade-off between Model size and resolution which is a compromise between usage of regional hard data and reservoir insight details

Repetitive Sequential process of building multiple siloed models

Not possible to re-purpose the existing static model for finer resolution modeling due to losing the resolution at previous grid resolution

Real Time Model update with inconsistent siloed sector models

Methodology, Procedure, Process

The methodology for this grid-less approach follows the standard geostatistical Modeling algorithms enabled by the point sets instead of grid cells.

Scalable Earth Modeling: This is the grid-less modeling technology which doesn't require a grid in place to start the geostatistical modeling. The well and seismic data are used at its own resolution to carry out the facies and petrophysical model using standard algorithms such as Truncated Gaussian Simulation (TGS) or Pluri-gaussian Simulation (PGS) for Facies Modeling and various algorithms like Turning Band Simulation

(TBS) or Collocated Co-kriging etc. The model provides full flexibility to generate different visualization at intended resolution without any requirement of building the model from scratch. This Modeling solution has the capability of integrating large data and building a single model covering multiple reservoir stacks or fields together for better consistency between individual scale and improve efficiency of performing the sub-surface modeling to accelerate the decision-making process. This dynamic scaling process without grids also brings the value of rapid model update with the new interpretation or data as there is no need of gridding and upscaling in the grid-less modeling approach.

ML Driven Property Composite: Considering the grid-less model doesn’t require any upscaling or blocking of the seismic and well data, the machine learning algorithms can run directly on point-based model to retain the resolution and create a Multi-composite volume which can further be used in a geostatistical model as a probability volume in the background. This ML model includes feature Engineering and selection process based on the statistical significance followed by the Random Forest and Gradient Boosting technologies to create composite volume extracted from multiple seismic attributes.

Geosteering and Live Earth Model update

As the Grid-less SEM model doesn’t require any gridding and upscaling process to get the data in the model, the model update has been seamless for SEM. The background property variogram can be re-used as-is with the new structural or well logs update at its own resolution without the requirement of repeating the whole workflow of gridding and facies & property modeling.

This grid-less modeling approach also offers to update the model at sector level or well scale for the operation geology purpose through visualization generation and at the same time taking the influence of all the data in the model which can further help in optimizing the performance of the static modeling with respect to the hardware specification.

In the conventional approach, in order to update the new data, the entire model needs to be run with the new data incorporation or need to extract a sector model near the well bore to drive the geosteering operation in which case that sector model gets disconnected from the parent large model. The “Scalable Earth Modeling” is intended to make a “Live Grid-less Model evergreening” which is flexible in terms of the resolution and model extent. Without building a new model, a sector around the well bore can be updated with the new data and high-resolution to guide the geosteering process and include new data in the large model seamlessly.

This grid-less modeling approach also helps to improve the horizontal resolution with its scalability (which is mostly destroyed in conventional parent gridded model) at the sector model for better incorporation of horizontal well data but at the same time connected to the all offset wells from parent model beyond the sector model area of interest for the model consistency. This way the consistency of geological model and the resolution of sector model both can be taken care of without any compromise.
Value Proposition

This workflow brings different value propositions on the table as below:

Faster evaluation of various Geological scenarios with the resolution changes

Evergreening the model with rapid model update with Real Time data

"Shared Earth Container" to bring consistency across fields or reservoirs by hosting multiple models together in a single container

Capability of handling big models to extract maximum insights

Consistent Sector or Well Model visualization for guided Geosteering

Re-purposing the static model based on Simulation result or various new exploration or development concept
Novel/ Additive Information

One of the novel workflows used here is Scalable Earth Modeling which is a grid-less modeling approach which builds the consistent multi-resolution geo-model. This workflow minimizes the inconsistency between reservoirs and fields by maximizing the usage of the data in a single model in an optimized way. The applicability of "Live Earth Model" concept ranges from development field model for FDP to integrated sector model at the operation geology tied to a single sub-surface model sufficing various purposes through a consistent multi-resolution model. This scalability also brings the value for horizontal drilling where the earth model can be downscaled to a better resolution in I and J direction from a lower resolution large field model without losing the consistency rather addressing heterogeneity in an evergreen Live Model. This is followed by implementing another innovative workflow solution Unified Ensemble Modeling which creates an orchestrated workflow to run the static and dynamic uncertainty modeling together to come up with history matched static and dynamic pairs to complete the feedback loop.