



Session 3: Embracing Innovation: AI and ML

EXPLAINABLE AI IN RESERVOIR MODELLING WORKFLOWS

V. Demyanov, D. Arnold, Q. Corlay, A. Nathanail, C. Sun, G. Shishaev, V. Starikov.

Heriot-Watt University, Edinburgh, www.geodatascience.hw.ac.uk, v.demyanov@hw.ac.uk

ABSTRACT

AI rapidly finds its place in reservoir modelling workflows capitalising on learning from data in information rich oil&gas applications. It is essential to position use of AI as a complementary tool aligned with core domain understanding of the first principles of the subsurface structure and its dynamics.

Reservoir modelling workflows are subject to large uncertainties on every step starting from interpretation of exploration data, coming up with a reservoir modelling concept, describing reservoir characteristics and property distribution, integration of dynamic data and model calibration and update as new data become available.

Reservoir modelling workflow implies: (i) discover patterns in geological and reservoir engineering data; (ii) describe variability and heterogeneity of subsurface properties; (iii) predict outcomes of subsurface resource development; and (iv) decide how to develop the resource confident proactive response to monitoring. All the above are subject to uncertainty associated with the data, their interpretation, modelling choices, inference from calibration to data and decision-making strategy at risk.

Modern development of AI tech opens outstanding opportunities to handle the above generic tasks with the methods designed to handle diverse and noisy data. AI is capable of discovering pattern data, describing complex geological patterns with dependencies learned from data, adapting models to data and searching for a range of possible optimal development options subject to uncertainty. Effective AI application to reservoir modelling workflows relies on the ability to ensure interpretability of the machine learning model outcomes. This can be achieved by embedding the domain context into the AI model structure, so the data are no longer treated as merely digital values but the variables with physical meaning and interpretation in subsurface context.

One of the still remaining challenges of AI applications is to make interpretative inference from learning from data rather than designing a “black box” predictive mechanism with little explanatory power. AI applications for subsurface modelling can gain both interpretability and explainability through embedding domain knowledge into the AI-system structure. This is achieved through accommodating particular structural dependencies within the AI learning mechanism that reflect geological/physics principles. While data arrangement as interpretable features gains explainability and performance in mimicking a natural system behaviour based on the domain understanding.

This overview demonstrates a few examples of how unsupervised and supervised learning algorithms applied in reservoir modelling workflows can gain interpretability and explainability in describing geological realism and



uncertainty for more accurate predictions and more efficient learning from data. AI applications covers several above listed tasks of reservoir modelling workflow (i, ii, iii, iv), specifically:

- 1) AI seismic interpretation and geobody detection (i) [1].
- 2) Constrain geological conceptual modelling with learning from outcrops (i) [2].
- 3) Generative facies modelling of meandering reservoirs based on learning from depositional process modelling (ii) [3].
- 4) Dynamic and static data integration with VAE and uncertainty representation via latent space to predict reservoir dynamic response (iii) [4].
- 5) Inform well operation decision-making based on PTA pattern recognition (iv) [5].

The overview illustrates the importance of embedding geological domain knowledge into the AI algorithms' structure to gains better understanding and representation of the uncertainty associated with the domain context.