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Application of Artificial Intelligence to the Petrophysical Interpretation of Logs

J. Strobel, Wintershall Holding GmbH, Barnstorf

Abstract

Classical log interpretation relies on physics-based formulas to compute net, porosity and saturation from logging data. These results are then often compared to core derived data and a manually driven iterative process is used to achieve a good match. While it is possible to employ relationships drawn from machine learning algorithms to optimize this match between the core and log data, the petrophysical community has only seldom adopted these non-physics-based approaches.

Several modern machine learning algorithms have become easily available recently. A fresh look into the application of these methods proofs to be beneficial:

In one application, plentiful log and core data are available. But even the most advanced conventional log interpretation methods do not produce a fully satisfying match of the core to log porosity. To overcome this, a reinforced learning algorithm was used through the adaptation of a genetic algorithm. This method minimized the log interpretation error by automatically adjusting the parameters while simultaneously shifting the core data´s depth slightly, optimizing the feedback strength. The result is a much-improved match of the core to log data. A further improvement is gained by adopting a Random-Forest algorithm to this already pre-refined interpretation and core shifts, resulting in a close to perfect match.

In another application, a field with almost 200 wells needed an interpretation for each well. But only 30 wells had logs that enabled a porosity interpretation. The others had solely SP and resistivity data whose relation to porosity is not clearly defined by physics. A hybrid learning approach was selected for this case. The 30 wells with complete log data were first analyzed conventionally and adjusted to core data. Then modern machine learning codes were used to train the SP & Resistivity portion of these wells´ data to re-create the porosity interpretation. After successful validation, this model was then applied to the remaining 160 wells and produced valid net, porosity and saturation results there. This approach was carried out twice and compared: Once applying sequential machine learning methods and once with a deep learning neural network algorithm.

Core data is always less plentiful and complete as desired. It is, therefore, a challenge to train any machine learning algorithm to log data as the correct answer is simply not known. This limitation can be overcome with advanced log simulation: Logs are simulated for a given lithology, porosity and saturation in a sophisticated process. These logs are then being utilized to train a machine learning code to replicate the original input porosity: Such a trained model is then quickly applied to similar, real-world data sets. This process overcomes the limitation of not having enough training data for successful artificial intelligence applications in petrophysical log interpretations.