

Real-Time Identification of Geological Factuals by Integrating Formation Micro Resistivity Imaging Logs With Computer Vision

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This paper was prepared for presentation at the GOTECH Conference held in Dubai, UAE, 7 - 9 May, 2024.

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Abstract

Reservoir characterization is pivotal for the success of oil and gas exploration, where sedimentary features significantly influence petrophysical properties and fluid flow behavior. This paper emphasizes the importance of accurately identifying and delineating these features, including bedding, cross-bedding, faulting, and fractures, to enhance reservoir characterization and efficiency. Using Formation Micro Resistivity Imaging (FMI) log as a powerful tool, this research focuses on leveraging Computer Vision (CV) and Deep Learning (DL) methodologies for the automatic analysis of FMI log.

The interpretation of FMI logs holds importance in reservoir characterization, modeling, natural fracture analysis, well completion design, and stress direction identification. Real-time interpretation is crucial for geo-steering and wellbore stability assessment. This study aims to leverage the power of CV and DL to provide accurate and real-time FMI interpretations, supporting daily drilling and completion operations.

The extensive datasets from FMI logs were processed, segmented, and clustered to identify various geological features. The CV model was trained on diverse geologic attributes, such as partially open fractures, Planner Laminated Siltstone, Massive Pyritic Mudstone, Laminated Arg. Sandstone facies, Calcareous Fossiliferous Mudstone facies, Low Angle Cross bedding, High Angle Cross bedding, Vuggy Dolomite, Fractured Dolomite, nodular limestone, glided mudstone, and other features. Subsequently, this model was deployed in real-time operations to interpret newly recorded FMI logs, validating its accuracy alongside expert interpretations.

During the model development, the optimum learning rate was found to be approximately 0.0052, successfully achieving the target. Through a carefully optimized training process, the model achieves an impressive overall accuracy of 92% in classifying over 50 geological features. Detailed insights into the model's performance are provided through the analysis of the confusion matrix and classification report. Further validating its robustness, the model is tested on a set of 100 unique images not included in the training set, showcasing a generalization capability with an accuracy exceeding 86%.

The CV model was evaluated with different metrics. The accuracy, precision, recall (Sensitivity or True Positive Rate), F1 score, and AUC-ROC (Area under the Receiver Operating Characteristic curve) of the model showed exceptional reliability of the model. Exceptional reliability was demonstrated, affirming its role in oilfield digital transformation. The model facilitated prompt wellbore stability and completion decisions, enabling the timely request of special needed logs without rig nonproductive time (NPT).

This research demonstrates the integration of advanced technologies in the analysis of FMI logs, offering a pathway to enhanced reservoir characterization.