Innovative GANs and AI for Well Log Data Synthesis, Imputation, and Anomaly Detection

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Abstract

Objectives: This study explores advanced applications of Generative Adversarial Networks (GANs) in enhancing well log data analysis. We employ sequence-based GANs for synthetic well log data generation and imputation, improving data availability and accuracy, while Ensemble GANs are utilized for detecting anomalies in well logs. The combined approach offers a robust solution for overcoming data gaps, inaccuracies, and uncertainties in well log interpretation.

Procedures: Using sequence-based GANs (TSGAN and SeqGAN), we generated synthetic well logs and performed precise imputation of missing data. The Ensemble GAN framework was applied to detect anomalies within well logs, benchmarking its performance against Gaussian mixture models (GMMs). The datasets used for this analysis include logs from the North Sea Dutch region, focusing on gamma ray, sonic, neutron porosity, and bulk density.

Results: The TSGAN and SeqGAN frameworks demonstrated superior accuracy in data generation and imputation, achieving R2 values as high as 0.921 with significantly lower errors compared to traditional methods. Ensemble GANs achieved higher precision (0.97) and F1 scores (0.98) for anomaly detection across various well logs, outperforming GMMs. These techniques contribute to enhanced data quality, reduced uncertainties, and improved decision-making in reservoir management.

Conclusions: The integration of sequence-based GANs and Ensemble GANs provides a comprehensive approach to addressing critical challenges in well log data analysis. This dual framework enhances data completeness through synthetic generation and imputation while improving the detection of anomalies, setting a new standard for well log interpretation in the digital era.