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Enhanced Fluid Discrimination in Reservoir Rocks Using Deep Learning-Based Seismic Inversion with Poroelastic Modelling

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Abstract : Seismic inversion is the most efficient technique that yields critical information for fluid differentiation inside reservoir rocks. Conventional approaches depend extensively on unreliable stochastic techniques and necessitate considerable computational resources and effort. Deep learning is an economical and effective approach for extracting complex patterns from data to provide accurate predictions. The lack of borehole label data, essential for training precise models, impedes its application. Moreover, the utilization of synthetic data is inadequate for producing data that aligns with actual geological conditions and necessitates additional modification of the trained models for practical applications. This study commenced with poroelastic modelling to mimic the bulk and shear moduli of rock using various saturating fluids. Subsequently, we employed the acquired moduli in empirical equations to calculate the density and velocities of the saturated reservoir, then computed Vp/Vs, Poisson's ratio, and acoustic impedance, which is critical for fluid analysis. This supplied essential labels for training multi-base inversion deep learning models with diverse topologies and hyperparameters. We integrated a prior knowledge component into the methodology to guarantee stability and compatibility with the local geological conditions. Subsequently, we assigned weights to individual models according to their accuracies and combined them to attain the most desirable outcome. The suggested method demonstrated superior performance compared to conventional inversion and popular deep learning approaches in a real-world application. This result is particularly crucial for understanding the reservoir's potential for oil and gas production as well as for predicting its behaviour under different conditions.

Keywords : deep learning, reservoir rock characterization, rock-physics models, seismic inversion
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