Invariant Information Clustering Models for Interpreting Seismic Images without Manually Annotated Supervised Labels

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ABSTRACT

Seismic interpretation process is crucial for locating hydrocarbons. Supervised image segmentation algorithms have received wide acceptance for seismic interpretations. However, these algorithms require expert annotated data and unsupervised algorithms present for these tasks in literature are vulnerable to degenerated solutions. This paper presents an application of Invariant Information Clustering (IIC), an unsupervised algorithm, for seismic data interpretation.

We start segmentation and interpretation of seismic data for identifying subsurface salt-deposits, using UNet, a deep learning model comprising an encoder-decoder network. While preparing data, it is observed that manual annotation of every pixel is resource intensive. This limitation was overcome by combining k-means clustering, an unsupervised learning algorithm with representation learning. At certain instances, this proposed combination results in a segment of a seismic image with no assigned pixels resulting in degenerate solutions. Finally, we implemented IIC, to maximize the mutual information present between different classes of pixels, i.e. salt or no salt, in the seismic image dataset. It randomly initializes Neural Network (NN) into a subsurface-characterization function and assigns different pixels of the provided seismic image to their respective classes. Output of the model does not require post-processing by geologists, it directly outputs the assigned class for each pixel.

Chaotic texture of salt deposits in seismic images makes its interpretation an extremely challenging task. We present the results of IIC in analyzing salt deposits. The model achieves an accuracy of 62.99% on the TGS salt identification dataset. The model trained using IIC learns the classifier and clusters the pixels of a seismic image into regions with salt and regions without salt. Results of modelling salt deposits opens possibilities for robust unsupervised modelling of other seismic interpretation tasks such as fault detection, facies classification etc.

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This paper is one of the first instances of demonstrating the application of IIC in seismic interpretation.