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Seismic Facies Segmentation Using Convolutional Neural Networks

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Introduction

Seismic facies segmentation is a fundamental process in reservoir characterization, stratigraphic analysis, and exploration of hydrocarbons. This process of seismic classification involves investigating the geological characteristics, such as reflectors, continuity, and amplitude, to assign each pixel to a specific category. Generally, this analysis is manual. However, seismic surveys consist of large datasets, making this process quite time-consuming and prone to errors, as it is subjective. In recent years, Artificial Intelligence techniques, such as Convolutional Neural Networks, have been proven to be a practical approach for seismic data in grid-like structures. Nevertheless, many deep learning models require a large volume of labeled data to extract seismic features and generate consistent results, which are often unavailable. To address this challenge, this work presents a methodology that employs a U-Net convolutional network architecture, trained with only 10% of the labeled data, to predict the remaining seismic data**.**

Method

The dataset used in this work was the Parihaka 3D seismic survey from the Taranaki Basin offshore New Zealand. The data consists of 590 inlines, 782 crosslines, and 1006 time samples, labeled into six categories based on geological characteristics. To extract such features, a U-Net architecture was employed to leverage its encoder-decoder structure and spatial data mapping capabilities. The applied methodology utilized two independent, trained models: one inline-oriented and the other crossline-oriented. In order to simulate the scenario of scarce data, only 10% percent of the data was used as training, selecting every seismic section tenth. The preprocessing included the normalization of the seismic amplitude and patching, segmenting the data into smaller chunks of 256 x 256. After training the models and predicting the seismic volumes in each direction, the results were merged. Each voxel class was defined by the highest probability amongst the predictions. This approach is designed to take advantage of the 3D data in each orientation.

Results and Conclusions

The performance was evaluated using Accuracy and Mean IoU. The crossline-oriented model achieved an accuracy of 91,6% and a 79.6% Mean IoU, while the inline model reached 95,4% accuracy and 85.2% Mean IoU. The merged one showed an enhanced performance, reaching an accuracy of 95.6% and 87.0% Mean IoU. The improvement in the accuracy was relatively small due to a significant class imbalance. However, the Mean IoU gain was noticeable, showing that the merged model is more precise in the underrepresented classes. Therefore, the proposed methodology has shown to be effective, by using a small amount of data and achieving promising results.