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The Impact of Deep Learning Seismic Denoising in 3D Elastic FWI of OBN Data

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Introduction

The application of Elastic Full Waveform Inversion (EFWI) in large-scale 3D imaging projects has emerged as a significant advancement in seismic data processing (Zhang et al., 2023; Nangoo et al., 2024). Given the substantial computational resources required for these methods, there are high expectations for the quality of the results. To enhance preprocessing efficiency and ensure superior outcomes, we investigate the impact of a deep learning denoising algorithm within the EFWI workflow.

Method

We used a supervised strategy to train the noise attenuation network with clean and noisy data. We evaluated three network architectures and chose SRGEN-4. The network was trained with 9 million patches and 22,400 seismic logs, using the ADAM optimizer and L1 loss. The training was conducted on a compute node with 384 GB of RAM and four NVIDIA V100 GPUs. Our elastic FWI approach is based on single-parameter elastic inversion, where modeled data is generated using elastic wave equation propagators and updates are calculated only for Vp. The objective function used is time lag-based, ensuring robustness against noisy data

Results

We applied the proposed workflow to the OBN data from a deepwater presalt field. Data from 954 stations covering an area of 111 km² were used. The comparison between the OBN seismograms showed that the noise attenuation algorithm via DL effectively attenuated the low-frequency noise while preserving the signal, which is essential to define the velocity model accurately.

Conclusions

Increased computational capacity is driving disruptive technologies in seismic processing: Elastic Full Waveform Inversion (EFWI) and deep learning (DL) algorithms. We showed a practical application in real 3D data, which benefited from the combination of these technologies, delivering a high-quality speed model with minimal human intervention in data pre-processing.

Despite wide-spread claims that FWI can be applied to raw data with no preprocessing, our findings reveal that a more robust denoising aids in the evaluation of time-shift objective functions for FWI. This can improve convergence, achieving a higher-resolution velocity model, when considering execution for the same frequency bands.