

Geo-ASCII: A Geoscience AI-assisted Seismic Conditioning and Iterative Interpretation workflow

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Conventional seismic interpretation and fault detection use manual picking, tracked picking, and seismic attributes for horizons and faults using routines such as OpendText auto-tracking and Petrel ant-tracking. This is cumbersome and leads to underutilization of data, as only a limited portion of all data is interpreted/picked in 3D surveys. We propose scaling up the interpretation of seismic data in the Dutch subsurface by interpreting and picking horizons and faults in the full range of data in Dutch 3D surveys instead of just a subset of inlines and crosslines using Machine Learning (ML) algorithms.

Next-generation Machine Learning tools that train and apply neural networks for automated horizon and fault detection have been developed already by market parties. Although generally successful and orders of magnitude faster, there are still many inaccuracies in these ML predictions compared to human interpretation/picking.

We have developed a ready-to-use AI software tool that uses seismic data and logs as input and generates output on predicted seismic horizons, geological units, and faults. For reducing accuracies and improving customization, we have inspected, conditioned, trained, retrained, and corrected state-of-the-art ML algorithms with the expertise and knowledge of human interpreters and available horizons and faults, such as Dutch Deep/Shallow NLOG datasets. We have cast this into a workflow for simple, user-friendly, low-threshold interaction with the ML tools. The application of the ML tools has been applied on onshore shallow to deep reservoirs/aquifers for HTO and geothermal exploration.

The first component of the workflow, AI data conditioning, performs automatic conditioning of seismic data on large amounts of 2D and 3D seismic data by doing denoising, interpolation and broadbanding. For that we use Self-supervised learning (“Noise2Void”, Birnie et al., 2021) and a Generative Adversarial Network (“MDA-GAN”, Dou et al., 2022, (a)).

Secondly, we automatically interpret geological horizons on large amounts of 2D and 3D seismic data. There we employ image segmentation using semi-supervised learning for classifying over- and underburden of given horizons, training on cleaned 3D Inlines and Crosslines (CONSS, Li et al., 2023).

Finally, we automatically interpret faults on large amounts of 2D and 3D seismic data. This is done by image segmentation with semi-supervised learning networks “FaultSSL” and FaultNet (Dou et al., 2022 (b), Dou et al., 2023) for fault detection in seismic data, training on Dutch 3D seismic cubes.

This Geo-ASCII workflow is demonstrated on several seismic datasets for the purpose of shallow and deep geothermal exploration. The workflow of these AI networks is mature and performs well on synthetic and field seismic data. Training on synthetic data always works well, training on field data is variable, the labels are not always consistent or correct and are scale variant. The 3D consistency of the AI predicted geological units, horizons, and faults is very convincing and usable, even in the shallow domain of the Dutch Maassluis and Oosterhout Formations.

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