

Attention Models Based on Sparse Autoencoders for Seismic Interpretation

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Abstract. One of the fundamental steps in the exploration of oil, gas, and hydrocarbons is to detect various subsurface structures such as faults, salt domes, gas chimneys and channels within seismic volumes. In recent years, with the dramatic increase in the size of acquired seismic data, manual interpretation is becoming extremely time consuming and labor-intensive. Attention models based on human visual system (HVS) can be utilized to mimic and predict the behaviour of interpreters inspecting seismic sections. Leveraging these models, we can not only automate the process of seismic interpretation but also develop new seismic attributes that highlight areas of interest in seismic sections and convey the most useful information in a compact manner. A recent trend is to apply machine learning techniques to design computational attention models by learning ground-truth eye-fixation patterns recorded from human subjects viewing natural scenes. However, the lack of such eye-fixation data for seismic interpretation has posed a limitation to developing learning-based attention models for seismic data. In this work, we overcome this limitation by first learning the variances among features of natural images that direct human visual attention, and then extracting such features from seismic images to study and recognize salient geological structures. Specifically, we propose a novel approach based on a data-driven sparse autoencoder architecture that can automatically extract features from unlabeled 3D seismic volumes. We train the autoencoder on natural images to derive higher dimensional sparse features. These features are then adapted to the seismic domain by utilizing seismic data to fine-tune the sparse autoencoder in a semi-supervised domain adaptation setting. Finally, a center-surround model is used to calculate the saliency for the seismic data in the feature domain. We demonstrate that the proposed autoencoder-based approach can effectively estimate salient structures within large seismic volumes, using real seismic datasets from the F3 block in the North Sea, Netherlands and the Great South Basin, New Zealand. The preliminary results demonstrate not only the capability of the proposed method in highlighting important structures such as faults and salt domes in an effective and accurate manner but also its potential for computer-aided extraction of other geologic features as well.