Submission code: WDWKJ5ARDV

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Focusing seismic method evaluation using attention-zone-based similarity metrics

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Introduction

Accurate evaluation of seismic data processing techniques is essential to ensure that critical subsurface structures are preserved. Traditional error-based metrics such as Mean Absolute Error (MAE) and Mean Square Error (MSE) quantify amplitude differences but fail to consider structural information. The Structural Similarity Index Measure (SSIM) partly addresses this by comparing local luminance, contrast, and structure. However, when relevant features occupy only a small part of the image, SSIM values may overlook local differences.

To overcome this, we propose a modified SSIM-based evaluation approach that emphasizes *attention zones* (AZs): specific regions of interpretative interest, such as faults or high-noise areas. By weighting the metric within user-defined AZs, we enable a more targeted and interpretable assessment of processing methods. While this work focuses on denoising filters, the method is applicable to other seismic processing tasks such as data reconstruction, interpolation, or structural enhancement.

Method

To produce a similarity map between a processed image and a reference, SSIM is computed locally over a sliding window . The Mean SSIM (MSSIM) is the uniform average of this map. We introduce the *Weighted SSIM* metric, where the similarity values are averaged using a binary or graded mask defining the AZs. This allows the metric to prioritize regions of greater geological or processing relevance. AZs can be defined manually or automatically using attributes, prior knowledge, or interpretative input.

We illustrate the proposed approach using a synthetic seismic section contaminated with random noise. Two denoising filters with different characteristics are applied, producing two outputs to be compared with the noisy reference. The evaluation is conducted both globally and within the AZs.

Results and Conclusions

In the synthetic example, MSSIM values are similar for both filters, making it difficult to distinguish their performance. This is expected, as the AZs represent a small portion of the image, limiting its influence on the overall metric. In contrast, the Weighted SSIM highlights clear differences within the AZs. For instance, one filter better preserves the continuity of a weak reflector within an AZ, while the other introduces distortions. These distinctions, critical for seismic interpretation, are captured only when the evaluation is focused on the relevant areas.

These initial results demonstrate the potential of the AZ-based approach as a flexible framework for performance assessment in seismic processing. It enables more meaningful comparisons by concentrating on regions crucial for interpretation. This methodology supports better-informed algorithm and hyperparameter choices, ensuring enhancements preserve geologically significant features. Beyond denoising, it can be extended to applications like data reconstruction or enhancement, making it a powerful and adaptable tool for seismic method evaluation. Though demonstrated on synthetic data, the method is designed to generalize across tasks and datasets, with ongoing work expanding its use to varied scenarios, including real data.