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# Automatic Construction of Structural Models by Image-Guided Ray Tracing

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## Introduction

Structural models derived from seismic image interpretation are widely used for various purposes, such as geological restoration, migration path definition, structure-oriented smoothing, property interpolation, and seismic inversion. Structural interpretation of seismic images is a fundamental step in this process and traditionally involves manual or semi-automatic analysis, which is time-consuming and requires specialized knowledge.

## Methodology and Theory

In this work, we propose an automatic approach for building structural models from seismic images. The structural models generated using this method are positive and monotonically increasing two- or three-dimensional functions, such that some of their level curves or surfaces align with interfaces and features present in the input seismic image. These lines and surfaces can thus be interpreted as belonging to a stratigraphic grid associated with the original seismic image. The proposed methodology is entirely based on image-guided ray tracing, where rays are the characteristic curves of a system of partial differential equations derived from conventional ray theory applied to the anisotropic diffusion equation commonly used in image processing algorithms. The diffusion tensor used in these equations plays the role of an anisotropic velocity field and is constructed from Gaussian derivatives of the seismic image amplitudes. A full description of this system and its applications can be found in Filpo et al. (2020).

The input seismic image is first subjected to a preprocessing stage, which may include frequency filtering, gain application, noise suppression, and trace interpolation. The preprocessed image is then used to construct the diffusion tensor, which guides the tracing of all rays in the methodology. The main parameters for ray tracing are: initial position, initial direction, and time step. The initial direction is directly derived from the diffusion tensor, while the initial positions are defined from a regular grid covering the entire seismic image.

To ensure structural continuity, the image is divided into overlapping segments, allowing rays traced in adjacent segments to act jointly in boundary regions. The final stage of the process consists of connecting pseudo-horizons formed by associating neighboring rays across the entire image.

## Results and Conclusions

The proposed methodology was successfully applied to several 2D synthetic and real seismic images with medium to high structural complexity. The 3D algorithm is currently under development, and preliminary tests indicate similar robustness as in the 2D case. Application examples of the developed method for property interpolation and tomographic inversion will be presented.

## References

Filpo, E., J. Costa, and J. Schleicher, 2021, Image-guided raytracing and its applications: Geophysics, 86, 39-47.