5543: An Algorithm for Evaluating Fresnel-Zone Textural Roughness for Seismic Facies Interpretation

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Abstract

In reflection seismic interpretation, a 1-D convolutional model is commonly used to interpret amplitude variations based on the geometric ray theory assuming seismic wave to reflect at a reflection point; however, the propagation of seismic waves actually occurs in a finite zone around the geometric ray path and gets reflected from a zone known as Fresnel zone. The collected signal at the surface turns out to be the superposition of micro-reflections from within the Fresnel zone, which is a function of texture (Gao, 2012).

Generally, for a rough texture such as sandstone, the dominant reflection is from the zone margin, while for a smooth texture such as marine shale, the dominant reflection is from the zone center. Based on this concept, Fresnel-zone texture directly affects amplitude variations with offset (AVO), azimuth (AVAZ), and frequency (AVF) (Gao, 2012).

Here we develop a computer algorithm for evaluating Fresnel-zone textural roughness. The algorithm starts with dividing the Fresnel zone into a set of micro-zones. It then builds an initial texture model to be convolved with an extracted wavelet. By comparing the synthetic signal from a Fresnel zone to the real seismic signal within an analysis window at a target location, the model is adjusted and updated until both synthetic and real signals match best. The roughness is evaluated as the correlation coefficient between the generated synthetic signal from a Fresnel zone to the real seismic signal within an analysis window at the zone center.

Algorithm Workflow

1. Load a 3D seismic amplitude volume.
2. Define the size of the Fresnel zone and a seismic wavelet.
3. Retrieve local waveforms centered at the target sample.
4. Estimate the dip-deviation histogram of micro-reflections within the Fresnel zone.
5. Compute the FzTR value from the estimated histogram.
6. Output of seismic FzTR attribute.

Fresnel-zone Textural Roughness (FzTR) = \( 1.0 - \frac{1}{\sqrt{N}} \sum_{i=0}^{N} R(i)^2 \)

0.0 for smooth texture

1.0 for rough texture

Conclusions & Further Work

In this study, we have

- Developed the first algorithm for evaluating FzTR from 3D seismic data;
- Applied this new method to a deep-water reservoir from offshore Angola;
- Identified channel fill and fan (sand) as high FzTR values;
- Marine shale is highlighted as low FzTR values.

Further work could focus on

- Defining the size of the Fresnel zone in a more accurate way;
- Implementing an analytical approach for estimating the dip-deviation histogram of micro-reflections in the Fresnel zone;
- Extending the algorithms to compute Fresnel-zone textural anisotropy (FzTA) and Fresnel-zone textural scale (FzTS).

Selected references