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Wavelet Transform Application in Seismic Discontinuity Detection

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Abstract

Of the image processing and pattern recognition techniques, wavelet transform has a long and successful history as it can locate significant variations and find subtle geological features within enormous seismic data volume. In seismic images, the opaque nature of the sedimentary layers often hides the boundaries between sedimentary packages. Basic statistical techniques can only classify seismic attributes based on wavelet characteristics and rapid amplitude changes, while fail to delineate relatively smooth discontinuities such as fault zones.

On the other hand, physical properties of the rock matrix and the fluid composition within the rock matrix will determine the degree to which energy is dissipated, and possibly change the characteristics of signals and finally cause those techniques to fail. The continuous wavelet has emerged recently as a key time frequency analysis and as an effective tool with high confidentiality. However in recent years, a number of approaches that can provide finer analysis are proposed successively such as ridgelet, curvelets, bandlets, and etc., which are more satisfactory in the 2D image processing. The standard edge detectors usually work well with high-quality images, but are not good enough for noisy images and not adequate for treating more complex discontinuities.

In this paper, we propose an analysis method based on wavelet characteristics for the estimation of seismic local discontinuities which is robust to noise and computationally efficient. As the characterization of seismic data greatly depends on wavelet characteristics, different wavelets in the Time, Frequency, and Cepstrum domains are extracted, then the relations between the characteristics of components of wavelet transforms are derived analytically and the coefficients of wavelet transforms are combined on a series of scales. A local search interval at the vicinity of each horizon is defined to determine the parameters for discontinuity detection.

It seemed that applying this novel technique enables us to detect the local discontinuities with greater stability in the presence of noise, and improved horizontal and vertical resolution. It can not only suppress the disturbance of the noise effectively but also keep up the consecutive and clear edges, and finally provides a more robust measure of coherency in complex discontinuities. Efficacy of this method in highlighting small perturbations is presented using synthetic and real data examples.