Impedance reconstruction using an hybrid regularized deconvolution in the Fourier and Wavelet domains

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Abstract

Acoustic impedance inversion is a technique for estimating acoustic impedance of subsurface layers from the stacked seismic data. If we consider the earth as a series of discrete impedance layers, then each interface has associated with it a reflection coefficient. A seismic trace is just this series of reflection coefficients convolved with a seismic wavelet. Inversion attempts remove the seismic wavelet from the reflection series. Once we have the reflection coefficients it is relatively simple process to reconstruct the impedance earth layers. However, the goal of recovering the acoustic impedance is not attained, for even if the earth is assumed to be made up of plane parallel layers having constant material parameters and the seismic convolutional model is adopted, there remains a fundamental problem to be overcome.

A basic, classical discrete-time deconvolution problem, where the inversion attempts remove the seismic wavelet from the reflectivity series, is used for testing an efficient, hybrid algorithm that performs noise regularization via scalar shrinkage in both the Fourier and wavelet domains, developed by Neelamani et al (2002). In this efficient algorithm, the Fourier shrinkage exploits the Fourier transform's economical representation of the colored noise inherent in deconvolution, whereas the wavelet shrinkage exploits the wavelet domain's economical representation of piecewise smooth signals and images.

The task is the recovery of the acoustic impedance from a band-limited reflection seismogram: For reaching it, it is necessary to perform the deconvolution of the desired reflectivity, from the observed data. The simple model is modified to include the presence of random noise.

The methodology includes performance of the deconvolution in the Fourier domain, and use of the Fourier- Wavelet Regularized Deconvolution (ForWaRD) operator. Both algorithms are compared, and estimates are obtained. These estimates are used as inputs for getting acoustic impedance estimates, simply solving an integral expression. The performance of both algorithms is illustrated using a 1-D deconvolution problem.

In conclusion, both deconvolution operators work well enough to get an estimate. However, ForWaRD works better removing the noise effectively. Based on it, this hybrid algorithm could be potentially employed in seismic deconvolution, which currently is being tested over a shot gather.