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AVO preserved velocity analysis using high-order Radon transform

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Extended Abstract

Summary

Velocity analysis is one of the most important stages of seismic processing. The most conventional method for velocity analysis is to calculate the semblance coefficients. Traditional semblance has some shortcomings, for instance, low resolution in time and velocity direction, high computational cost, and having trouble in presence of amplitude variation-with-offset (AVO) phenomenon. In order to compensate for the latest shortcoming, AB semblance has been proposed. However, this method has approximately twice the lower resolution than traditional semblance. On the other hand, due to effects of the source wavelet, seismic events have band-limited nature, which leads to a decrease in temporal resolution. Recently, the deconvolutive Radon transform has been introduced to overcome the latest problem. In this paper, we have developed the deconvolutive hyperbolic Radon transform for AVO preserved velocity analysis. We have also used the log-polar domain in order to reduce computational cost. We tested this method on both synthetic and real field data sets to show resolution improvement in the proposed method.

Introduction

Velocity analysis is one of the most important steps in seismic data processing and interpretation. It affects many processes of seismic data processing, such as NMO correction, stacking, and time and depth migration. There are several methods for calculation of velocity spectra. The most conventional method for velocity analysis is based on moveout of reflection events, which uses the coherency. Semblance is the most conventional coherency measure, which is defined as normalized output to input energy ratio of a windowed hyperbola. Although it is functional in most circumstances, it has some problems such as low resolution in time and velocity direction, and lack of velocity peak in the presence of strong variations of amplitude along seismic events (AVO) or polarity reversals. In order to overcome the later problem, AB semblance has been introduced. However, it suffers from lower resolution compared to conventional semblance. In this papr, high-order sparse deconvolutive Radon transform has been employed to increase the resolution of velocity spectra.

Methodology and Approaches

Since the basic functions in Radon transform are independent of the data which is to be analyzed, the Radon transform is a non-adaptive transform. Due to effects of the source wavelet, seismic events have band-limited nature, while basis functions of Radon transform are Dirac delta functions in time. This leads to a decrease in resolution. Recently, the deconvolutive Radon transform has been introduced in order to overcome these problems. This method can be defined as a blend of deconvolution and Radon operators.

The conventional Radon transform sums the amplitudes along trajectories for a specific time and velocity values and does not consider AVO characteristics of seismic data. To avoid this drawback, high-order Radon transform has been introduced . This method combines the conventional Radon transform with the orthogonal polynomial transform. As a consequence, it can estimate the seismic data more accurately by using a few polynomial coefficients to represent its AVO characteristics. In this paper, we have used higher order of deconvolutive Radon transform to overcome the AVO problem and enhance the resolution in time direction. Moreover, by applying fast iterative shrinkage-thresholding algorithm (FISTA), a high-resolution velocity panel is obtained. The main step of this algorithm involves the computation of the forward and adjoint operators, which in the case of hyperbolic Radon transform can be very time-consuming. In order to reduce the computational costs, we have rewritten the Radon transform in log-polar coordinates.

By doing so, the main computational parts are attributed to compute convolutions, which can be computed rapidly in frequency domain. In order to use frequency domain, samples in log-polar coordinates must be chosen on an equally spaced grid; Thus, interpolating is required for switching between log-polar and time-offset coordinates.

Results and Conclusions

In this paper, we have developed the deconvolutive hyperbolic Radon transform for AVO preserved velocity analysis. This method is based on higher order of deconvolutive hyperbolic Radon transform. This method significantly improves the resolution of velocity analysis in presence of AVO. The method has been examined by applying it on real field and synthetic data. The results from these tests have confirmed the above claims.