Reflection-based Traveltime Inversion Using Segment Dynamic Image Warping

Lu Liu

Aramco Research Center - Beijing, Aramco Asia

Abstract

Objectives: We propose a new method of segment dynamic image warping (SDIW) for wave-equation reflection travletime inversion. SDIW can provide reliable time shifts between the demigrated and observed data even if the signal-to-noise ratio of input data is rather low. **Procedures:** Conventional methods for estimating time shifts are based on crosscorrelation or manual picking; however, these methods are prone to error when the initial is far away from the complex true model. We propose using the SDIW for reflection traveltime inversion. The classic dynamic time warping can match one time series with another by providing a pathological results. It tries to explain the variability in amplitude-axis by warping the time-axis. This may cause the algorithm to fail to find an intuitive alignments, when a feature in one time series is slightly higher or lower than its associated feature on another series. To avoid the amplitude influence and match the trend of various reflection events, we propose SDIW to compute the time shifts. SDIW first exploits windowed polynomial fitting for signal processing and then aligns the signals based on point-wise segment-to-segment matching. Compared with the conventional point-to-point matching strategy, our method is more robust and insensitive toward strong random noise. **Results:** We validate our method on partial Sigsbee 2A model. We use laterally homogeneous velocities that increase linearly with depth as the initial model to test the robustness of our method when the initial models are reasonably far from the expected realistic ones. 400 shot gather are uniformly simulated with a 16 Hz Ricker wavelet as source and one-way wave equation as engine. Each shot has 500 receivers uniformly distributed on the surface with the spacing of 15 m. The maximum recording time is 6.0 s, and the time sampling interval is 2 ms. The results show that SDIW-based wave-equation reflection travletime inversion method provides a good initial velocity model for full-waveform inversion (FWI) on strongly noisy data, and starting from that, FWI can build a high-fidelity velocity model without low frequencies. **Conclusions:** A new method of SDIW is proposed for wave-equation reflection travletime inversion to build the deep background velocity model for the subsurface of earth. In a robust manner, SDIW is capable of retrieving traveltime shifts between observed and demigrated reflections using windowed polynomial fitting and point-wise segment-to-segment matching for the cases with strong noise. With the reliable shifts provided by SDIW, DRTI accurately reconstructs long-wavelength components of the velocity model and achieves a satisfactory depth-domain image for interpreting the geological structures.