Reflection Full Traveltime Inversion in the Image Domain

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ABSTRACT

Full traveltime inversion (FTI) is a newly developed wave-equation-based traveltime inversion methodology to automatically invert a kinematically accurate velocity model from traveltime information. Many previously published wave equation-based methods, which attempt to automatically invert traveltime or kinematic information in seismic data or migrated gathers for smooth velocities, suffer a common and severe problem ---- the inversion are involuntarily and unconsciously hijacked by amplitude information. FTI explicitly extracts the traveltime-related component from the original gradient, thus prevent amplitude interference during the inversion. In the image domain, The FTI theory can be used to characterize the transmitted wavepathes of the reflected waves. FTI makes an assumption that as the velocity model changes, there is only a time shift of the focusing energy in the extended common image gather. In this way, an image perturbation is completely characterized by the traveltime shift of the focusing energy, and the FTI gradient can be derived based on traveltime-oriented strategies. Compared to the Born or DSO gradient, the FTI gradient has much less artifacts. We have applied FTI to a 2D marine line segment from the Red Sea. This streamer dataset is acquired by using 1891 shots with 20 m shot interval which covers a distance of 37.8 km. For each shot, there are 285 active hydrophones with 20 m spacing. Surface offsets range from 320 m to 6000 m. The data are filtered to the frequency of 5-45 Hz. Actually the frequencies below 5 Hz are missing from the data. Preprocessing of this data includes refraction energy removal and internal multiple elimination on pre-stack gathers. The challenge of this example is that we attempt to invert for the salt body from an initial model without salt information. After inversion the velocity shows well-defined boundaries of both top salt and bottom salt. The subsurface-offset gathers with inverted velocity become more focused. At the same time, the angle gathers show significant improvement in flatness. In addition, the inversion result is also consistent with the well log here. The test demonstrates the excellent convergence behavior of FTI. It does not require an accurate initial models or low-frequency seismic data. It is capable to recover both the top and bottom salt boundaries without low frequency, even if starting from a simple initial model without any salt information.