Statistical Depth Imaging with Path Summation through Complex Near-Surface

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Abstract

OBJECTIVES/SCOPE: In land seismic exploration, strong scattering caused by small- and medium-scale near-surface heterogeneities strongly deteriorates the quality of depth seismic images. While the imperfections in the migration velocity model prevent the images from proper focusing, accurate reconstruction of all the near-surface complexities is likely out of reach by modern algorithms. Since the near-surface model itself is often not a primary object of interest, a reasonable workaround considers it as some stochastic media. By evaluating and using statistical properties of this media, imaging algorithms might mitigate the near-surface- and overburden-related challenges and produce more accurate images of deep horizons.
METHODS, PROCEDURES, PROCESS: One of the ways for imaging without knowing an exact velocity model uses a concept of path-integral summation. The main idea is to stack all possible images obtained from an ensemble of velocity distributions instead of using a single "best" one as in conventional algorithms. The ideas of path-integral seismic imaging were explored in several applications in the time domain, including stack to zero offset, time-migration, velocity analysis, and diffraction imaging. Extending these ideas to depth imaging is more challenging due to the need to adequately sample the multidimensional space of possible depth velocity models and choose suitable weighting functions for the summation.
RESULTS, OBSERVATIONS, CONCLUSIONS: In this study, we show an initial investigation of the path-summation approach for depth imaging of target deep reflectors in the presence of a complex near-surface scattering layer. We characterize such layer as a random, cluttered medium that remains unknown but whose statistical properties can be guessed or estimated from the data. Based on a synthetic example with complex near surface simulated as a fixed realization of a random Gaussian field, we demonstrate that the path-summation image tends to provide more focused and better resolved image comparing to more conventional approaches. Notably, the path-summation image tends also to contain less artifacts comparing to the ideal migration result from the true clutter model. This synthetic example shows a potential of statistical depth imaging based on a path-summation approach in the areas with complex near-surface.
NOVEL/ADDITIVE INFORMATION: The presented approach for depth seismic imaging through complex near-surface using path-integral summation is a novel method that have a potential to eliminate distortions in the wavefield propagationIlya