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Please fill in your abstract title.	Walkaway VSP Velocity Estimation Using Nonlinear Inversion Framework

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Abstract

An accurate velocity model is an essential component for constructing an enhanced image of the subsurface. The velocity model can be estimated from a walkaway vertical seismic profiling (VSP) first breaks. Therefore, the objective is to develop a robust nonlinear traveltime inversion framework for constructing accurate velocity models to be used for imaging the subsurface in the vicinity of the borehole. First, a three-dimensional gridded velocity model is adopted in which traveltimes are accurately computed using an algorithm based on the eikonal equation. The algorithm requires a large number of forward modeling computations when the discretized 3D medium has a large number of nodes. Furthermore, the cost and accuracy of the forward modeling algorithm are directly proportional to the medium sampling. Therefore, one can improve the constructed velocity model by reducing the grid size, thus increasing the number of grid points. Second, the ray-path connecting each receiver-source pair is calculated using an algorithm based on Fermat's principle. The ray-paths for all receivers are, later, used for constructing an L_2 objective function together with its gradient. Third, an iterative quasi-Newton method employing the BFGS updating formula is deployed to build an updated velocity model. The objective function may have multiple minima because the ray-path depends on the velocity field; therefore, one may need to pay special attention to the starting velocity model.

To build the velocity model accurately, there have to be many receiver stations well positioned within the borehole. The coordinates of such receiver stations, also, need be determined with high accuracy to reduce the errors in the reconstructed velocity model. The same applies for the sources when the situation allows, as is the case when one is probing the subsurface with walkaway VSP. Equally important are the picked first arrival times. The observed data accuracy, including the measuring precision and the errors estimation, is essential for reconstructing an accurate velocity model using a gradient-based method. Tests on VSP synthetic and real datasets demonstrated the robustness of the proposed framework to estimate accurate velocities.

The proposed framework resolves the problem into two phases in an iterative manner. First, the forward modeling phase through which the objective function and its gradient are constructed based on the current velocity model. Second, the optimization phase where the quasi-Newton algorithm is used to minimize the objective function with a few number of iterations; hence partially update the velocity model. This is to safeguard against falling into a local minimum as the problem is highly nonlinear.