Abstract

Amplitude-preserving migration based on a weighted diffraction stack is a task of high computational costs. Three factors determine the major contributions to the computational effort: The diffraction time surface must be computed for each image point as well as proper weight functions. Finally, the summation is carried out over the whole aperture of the experiment.

I propose a new strategy for amplitude-preserving migration that is entirely based on traveltimes, thus called traveltime-based true-amplitude migration. Its foundation is a hyperbolic traveltime expansion. High accuracy is achieved because second-order spatial derivatives are included in order to acknowledge the curvature of the wavefront. The algorithm permits the determination of the interpolation coefficients from traveltime tables sampled on a coarse grid, thus reducing the requirements in data storage. The method also provides a tool for the interpolation between sources. Application to various velocity models confirms that savings up to a factor of 10^5 are possible in data storage with no significant loss in accuracy. Also, the interpolation is 5-6 times faster than the calculation of traveltime tables using a fast finite differences eikonal solver.

Since it is possible to express true-amplitude weight functions in terms of second-order traveltime derivatives a traveltime-based relationship for the weights can be established. As a consequence, the weight functions can be directly computed from the interpolation coefficients. This reduces the need in computational time, and particularly storage, because the weights are computed on-the-fly. Application of the weight functions shows good agreement between numerical and analytical results for the simple type of models considered in this work. For complex models the good accuracy of the geometrical spreading, which can be computed using the same interpolation coefficients as for the weight functions, was also demonstrated. This indicates that the migration technique will also perform well for complex models.

A further significant reduction of the computational effort involved in the migration can be achieved if the summation is carried out only over those traces that really contribute to the stack, i.e. by limiting the migration aperture. Moreover, the optimum migration aperture can also be determined from the traveltime coefficients. Examples show that limited aperture migration reduces the requirements in computational time by 80% in 2-D, and by more than 90% in 3-D media. At the same time, the image quality is enhanced by suppressing migration noise.

Since the foundation of the method, the hyperbolic traveltime expansion, is not limited to isotropic models the technique has a high potential to be extended to anisotropic media.