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Efficient algorithms for two-point seismic ray tracing in layered media using the Newton-Raphson method

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The issues of tracing a ray and finding its travel time have been objects of significant interest in geophysics. An accurate set of data on both ray path and travel time would make it possible to reconstruct a seismic image that effectively illustrate complex geological features beneath the surface. In this study, we propose new efficient and accurate two-point ray tracing algorithms using the concept of Newton-Raphson method of locating roots to solve for the ray path corresponding to the minimal travel according to the Fermat's principle. The Newton-Raphson method (the Newton's method) of locating roots is chosen among others to solve this problem because of its quadratic convergence. Even though some difficulties are expected due to our choice of the Newton's method such as a failure to converge to the roots because of poor initial estimate, and difficulty in calculating the derivative of a function, the Newton's method provides a quick and efficient way to minimize the travel time function accurately in the case where appropriate initial conditions are given.

Three sets of algorithms have been developed including algorithms for zero-offset model, CMP Pre-stack model, and constant velocity multi-layered model. The issue of finding a good scheme to estimate appropriate initial conditions and other minor stability problems are currently under investigation to improve the performance of the algorithms. Future works include multi-layered model with velocity gradients, and three-dimensional model.

Algorithms developed in this study will be included in *Madagascar*, an open-source software package for multi-dimensional data analysis. Anyone who is interested can readily access the source code of each model and use other existing tools in *Madagascar* to reproduce the same results I have reached or apply the algorithms to other problems of their interest.

Keywords: two-point ray tracing, Newton-Raphson method