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Square-Root Variable Metric based Elastic Full Waveform Inversion and Uncertainty Estimation

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Full-waveform inversion (FWI) is a powerful tool in inverting high-quality subsurface geophysical properties; however, its uncertainty estimation is equally important and still left behind. The uncertainty estimation is theoritically linked with the inverse Hessian (or posterior covariance matrix), which is prohibitive to store for practical problems. Conventionally, the numerical methods for solving FWI are gradient-based, such as steepest-descent, conjugate-gradient and L-BFGS. Among them L-BFGS stands out such that we take it for reference. In this study, we investigate the application of the square-root variable metric (SRVM) method, a quasi-Newton optimization algorithm, to elastic FWI in a vector version. The number of SRVM vectors equals the number of iterations, and each vector is at the same size with the model. This approach may allow us to reconstruct the final inverse Hessian at a storable memory cost. We conduct SRVM based elastic FWI on the elastic Marmousi Model. We compare the results against those by the state-of-the-art L-BFGS. After the elastic FWI is done, we can have access to its posterior covariance by reconstructing the inverse Hessian with memory-affordable SRVM vector series. We extract the posterior standard deviation and draw the posterior random samplings to measure the uncertainties of our elastic FWI.