

A Two-Stage Markov Chain Monte Carlo Method for Seismic Inversion

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Markov chain Monte Carlo (MCMC) methods produce information that is extremely useful for uncertainty quantification for a variety of applications including seismic inversion. However MCMC is computationally a very expensive process. In fact, to determine whether velocity samples should be included in the chain requires repeated solution of the forward problem, and a large proportion of these models are ultimately rejected. To reduce computational expense, we propose a two-stage MCMC algorithm that uses a coarse-grid filter to quickly reject unacceptable proposals generated in the process. We demonstrate the two-stage MCMC algorithm on the seismic inverse problem of determining layer depths and velocities. Our filter stage uses operator upscaling applied to the acoustic wave equation which provides near-perfect speedup in parallel with no communication between processors. The coarse grid wave equation solution produces data that is highly correlated with the data obtained from the full fine-grid solution, thereby ensuring that the upscaled solution a good filter. Typically the two-stage MCMC run accepts 10 times more samples in the Markov chain than traditional MCMC. Our experiments recover the true velocity field and produce posterior distributions that are useful for uncertainty quantification.