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Adjoint analysis and its application in full waveform seismic inversion

In this work we focus on the development of an efficient and accurate computational method for solving the adjoint-based full waveform seismic inversion problem. The physics model considered is a 2D acoustic wave equation with heterogeneous velocity model. Seismic data are recorded on the earth's surface. The inverse problem is formulated as a PDE-constrained nonlinear optimization problem in which the parameters to be estimated is the velocity model. Given the high heterogeneity of the earth, a large number of parameters are expected in the optimization problem, which makes it necessary to apply gradient-based local optimization algorithm. Adjoint state method has been proved to be an effective and accurate approach to derive the gradient of the objective function with respect to a large number of model parameters. Here in this work we use a powerful adjoint analysis tool: perturbation theory to derive the adjoint wave equation, which is then numerically solved to compute the adjoint variable for the purpose of gradient computation. Some numerical examples in seismic imaging problems are presented to illustrate the effectiveness and efficiency of the proposed method.