A model reduction approach to numerical inversion for a parabolic partial differential equation

Alexander Mamonov
University of Texas at Austin

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Abstract

We propose a novel numerical inversion algorithm for parabolic partial differential equations, based on model reduction. The study is motivated by the application of controlled source electromagnetic exploration, where the unknown is the subsurface electrical resistivity and the data are time resolved surface measurements of the magnetic field. The algorithm presented in this paper considers a layered medium. The reduced model is obtained with rational interpolation in the frequency (Laplace) domain and a rational Krylov subspace projection method. It amounts to a nonlinear mapping from the function space of the unknown resistivity to the small dimensional space of the parameters of the reduced model. We use this mapping as a nonlinear preconditioner for the Gauss-Newton iterative solution of the inverse problem. The advantage of the inversion algorithm is twofold. First, the nonlinear preconditioner resolves most of the nonlinearity of the problem. Thus the iterations are less likely to get stuck in local minima and the convergence is fast. Second, the inversion is computationally efficient because it avoids repeated computations of the time domain solutions of the forward problem. We study the stability of the inversion algorithm for various rational Krylov subspaces, and assess its performance with numerical experiments.

This talk should be accessible to graduate students.