GLOBALLY CONVERGENT NUMERICAL METHODS FOR SEVERAL INVERSE PROBLEMS BASED ON CARLEMAN ESTIMATES

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Abstract

This dissertation is focused on developing efficient numerical methods and theoretical analysis for solving various inverse problems that arise in the fields of mathematics, physics, engineering, and beyond. We propose in this dissertation a unified framework with two stages to solve severely ill-posed and highly nonlinear inverse problems. In the first stage, we derive a system of partial differential equations by introducing a new variable and truncating the Fourier series of the solution to the governing equation. In the second stage, we solve the system derived in the first stage using the quasi-reversibility method, the Carleman contraction mapping method, and the convexification method. The obtained solutions of this stage directly yield the desired solutions to the inverse problems. An important contribution of the dissertation is that we will rigorously and numerically prove the efficiency of this framework, including its global convergence to the true solution. The analytic proofs are based on some Carleman estimates, and the numerical proofs are provided by successfully testing our methods with highly noisy simulated data and experimental data provided by US Army Research Laboratory engineers.