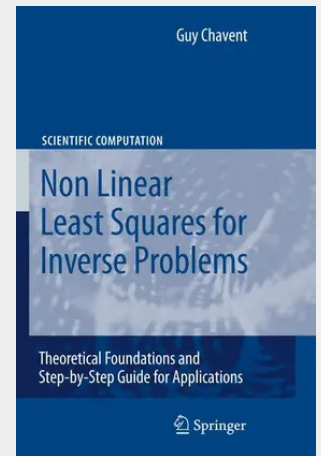


Nonlinear Least Squares for Inverse Problems

Theoretical Foundations and Step-by-Step Guide for Applications

The domain of inverse problems has experienced a rapid expansion, driven by the increase in computing power and the progress in numerical modeling. When I started working on this domain years ago, I became somehow frustrated to see that my friends working on modeling were producing existence, uniqueness, and stability results for the solution of their equations, but that I was most of the time limited, because of the nonlinearity of the problem, to prove that my least squares objective function was differentiable. But with my experience growing, I became convinced that, after the inverse problem has been properly trimmed, the final least squares problem, the one solved on the computer, should be Quadratically (Q)-well-posed, that is, both well-posed and optimizable: optimizability ensures that a global minimizer of the least squares function can actually be found using efficient local optimization algorithms, and well-posedness that this minimizer is stable with respect to perturbation of the data. But the vast majority of inverse problems are nonlinear, and the classical mathematical tools available for their analysis fail to bring answers to these crucial questions: for example, compactness will ensure existence, but provides no uniqueness results, and brings no information on the presence or absence of parasitic local minima or stationary points.

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