Department of Mathematics,
University of California San Diego

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Math 278C: Optimization and Data Science Seminar

Prof. Zhonggang Zeng

Northeastern Illinois University

Numerical Solutions of Ill-posed Problems: A Geometric Perspective

Abstract:

Arising frequently in sciences and engineering, ill-posed problems remain a formidable challenge and a frontier in scientific computing because their solutions appear to be infinitely sensitive to data perturbations. Many common algebraic problems are ill-posed, such as matrix rank, singular linear and nonlinear systems, polynomial factorizations and Jordan Canonical Forms. On the other hand, the instability of such problems may be a "misconception", as argued by W. Kahan 40 years ago, since the solutions are well behaved when certain structures of the problems are preserved. Furthermore, the hypersensitivity is not random but one-directional: Tiny perturbations can only decrease the singularity of the problem and never increase it. From a geometric perspective, ill-posed problems with a specific structure form a smooth manifold that is embedded in similar manifolds of lower codimensions. Based on this property and the Tubular Neighborhood Theorem, ill-posed algebraic problems can be regularized to remove the instability through two optimization problems: Maximizing the codimension of nearby manifolds and minimizing the distance from the manifold to the data point. In this talk we shall elaborate the computing strategy based on the regularization approach along with algorithms/software for finding accurate solutions of many ill-posed algebraic problems from empirical data.

Host: Jiawang Nie

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