

CS 790 - Math 752: Inverse Problems in Imaging - Spring 08

Instructor

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Lectures

The class meets Tuesdays and Thursdays from 9:30 to 10:45 in Manchester, Room 245.

Prerequisites

Calculus of Several Variables, and a beginning course in Numerical Analysis (or you should review this background material).

Text

"Deblurring Images: Matrices, Spectra, and Filtering", P. Hansen, J. Nagy, and D. O'Leary, SIAM Press, Philadelphia, 2006. Paperback copies are available. We will also use other resources, and some lecture notes will be provided.

Course Themes

Inverse problems are problems where causes for a desired or an observed effect are to be determined. They have, nearly always driven by applications, been studied for nearly a century now. An important key feature, both theoretically and numerically, of inverse problems is their ill-posedness, i.e., they do not fulfill Hadamard's classical requirements of existence, uniqueness and stability, under data perturbations, of a solution: Solutions of an inverse problem might not exist for all data (e.g., a consistent temperature history exists only for a very smooth final temperature in the model of the classical heat equation), it might not be unique (which raises the practically relevant question of identifiability, i.e., the question if the data contain enough information to determine the desired quantity), and it might be unstable with respect to data perturbations. The last aspect is of course especially important, since in real-world problems, measurements always contain noise (another source of noise being errors in numerical procedures), and approximation methods for solving inverse problems which are as insensitive to noise as possible have to be constructed, so-called regularization methods.

The course will concern "Emerging Applications of Inverse Problems Techniques to Imaging Science". These include medical imaging, atmospheric imaging, biometrics, integrating optics and imaging, and computer vision techniques.

We will concentrate on: (1) mathematical principles useful in solving inverse problems in science, medicine, and engineering, (2) techniques for solving modest size inverse problems using the Matlab Image Processing and Optimization Toolboxes, (3) methods for solving large scale inverse problems.

Problem Sets & Grading

There will be 3 projects (1 individual/2 group), a midterm (take home), and a final exam (take home). Course grades will be determined using the following weighting: individual problem set - 10%, group problem sets with class presentations - 20% each, mid-term and final exams - 25% each.