MATH 8070–Topics in Numerical Analysis for Inverse Problems
Syllabus

Textbooks: Per Christian Hansen, Discrete Inverse Problems: Insight and Algorithms
Curtis R. Vogel, Computational Methods for Inverse Problems

Per Christian Hansen, Discrete Inverse Problems: Insight and Algorithms

Chapter 2: Meet the Fredholm Integral Equation of the First Kind
- 2.1 A Model Problem from Geophysics
- 2.2 Properties of the Integral Equation
- 2.3 The Singular Value Expansion and the Picard Condition
- 2.4 Ambiguity in Inverse Problems
- 2.5 Spectral Properties of the Singular Functions

Chapter 3: Discretizations of Linear Inverse Problems
- 3.1 Quadrature and Expansion Methods
- 3.2 The Singular Value Decomposition
- 3.3 SVD Analysis and the Discrete Picard Condition
- 3.4 Convergence and Nonconvergence of SVE Approximation
- 3.5 A Closer Look at Data with White Noise
- 3.6 Noise that Is Not White

Chapter 4: Computational Aspects: Regularization Methods
- 4.1 The Need for Regularization
- 4.2 Truncated SVD
- 4.3 Selective SVD
- 4.4 Tikhonov Regularization
- 4.5 Perturbation Theory
- 4.6 The Role of the Discrete Picard Condition
- 4.7 The L-Curve

Curtis R. Vogel, Computational Methods for Inverse Problems

Chapter 1: Introduction
- 1.2 Regularization by Filtering
- 1.3 Variational Regularization Methods
- 1.4 Iterative Regularization Methods

Chapter 2: Analytical Tools
- 2.1 Ill-posedness and Regularization
- 2.2 Regularization Theory
- 2.3 Optimization Theory
- 2.4 Generalized Tikhonov Regularization

Chapter 3: Numerical Optimization Tools
- 3.1 The Steepest Descent Method
- 3.2 The Conjugate Gradient Method
- 3.3 Newton's Method
- 3.4 Inexact Line Search

Chapter 6: Parameter Identification
- 6.1 An Abstract Framework
- 6.2 A One-Dimensional Example
- 6.3 A Convergence Result

Chapter 7: Regularization Parameter Selection Method
- 7.3 The Discrepancy Principle
- 7.4 The L-Curve Method
- 7.5 Analysis of Regularization Parameter Selection Method