Quantitative Methods In Environmental Geophysics

Tuesdays 6 - 9pm

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Office Hours: TBA
Office Location: Smith Hall Room 135

Course Description:

The class will present a comprehensive study of the theory and practice of geophysical inversion. Inverse methods are used to transform geophysical data into a physical model of the subsurface, which allows geophysicists to draw meaning from their data. The focus of this class will be the application of geophysical inverse methods in environmental geophysics and hydrogeophysics; however, the material of the class will be relevant to many areas of applied geophysics.

Course Objectives:

By the end of this class you will have:

- An understanding of geophysical inverse theory and its application to environmental geophysics.
- Experience writing a basic geophysical inversion algorithm.
- An understanding of regularization techniques and their impact on an inverted image.
- An understanding of the link between geophysical data and the inverted model.

Course Expectations:

The class consists of one three-hour lecture a week. Attendance during class is strongly recommended. Although there is a required text for this course, the material covered will draw from multiple sources and will be difficult to obtain from outside the class. **Out of consideration for your classmates, please arrive on time, refrain from using laptop computers during class, and turn off your cell phone.**

There will be one quiz each class that will address the material covered in the pervious lecture. Each quiz will be worth 5 points and you will either get 5 points for answering the questions or 0 points for an incomplete quiz.

There will be a weekly assignment that will address theory learned in class. These assignments are to assess your understanding and you are encouraged to work with peers and ask the instructor to help improve your understanding.

There will be one in class midterm and one final exam for this class.

Late Assignment Policy:

Students will be allowed two "free" late assignments during the quarter; a late assignment is an assignment that is handed in after the end of class. For the third late assignment 10% will be docked for each day late. These assignments must be handed in no later then the Friday after the assignment due date, assignments handed in later than the Friday following class will not be accepted.

Grading Basis:

The grade for the class will be distributed as follows

Weekly Assignments	30%
Weekly Quiz	15%
Midterm	25%
Final	30%
Total	100

Reference Material:

Required Text:

R. Aster, B. Borchers, and *C. Turber* (2005) Parameter Estimation and Inverse Problems, Elsevier Academic Press.

Suggested Reading List and Reference Texts:

J. A. Scales, M. L. Smith, and *S. Treitel* (2001) Introductory Geophysical Inverse Theory, Samizdat Press. (available online at: http://landau.mines.edu/~jscales/gp605/snapshot.pdf)

D. Oldenberg, Inversion for Applied Geophysics learning resource package. (A free, online resource http://www.eos.ubc.ca/research/ubcgif/)

A. Tarantola (1987) Inverse Problem theory and Methods for Model Parameter Estimation, SIAM. (full text available online at: http://www.ipgp.fr/~tarantola/Files/Professional/Books/index.html)

G. Strang (1976) Linear Algebra and its Applications, Academic Press.

Course Schedule:

Date	Class Topic	Reading	Assignment
	• Syllabus • Introduction to Inverse Theory • Review of Linear Algebra	Chapter 1 Appendix A.1, A.2, A.3	Assignment 1 handed out
	• Norms • L2 estimates (Least Squares) • Derivation of Normal Equations	Appendix A.7 Chapter 2.1	Assignment 1 due Assignment 2 handed out
	• Review of Probability and Statistics • Chi-squared tests	Appendix B Chapter 2.2, 2.3	Assignment 2 due Assignment 3 handed out
	• Maximum Likelihood • L1 estimates	Chapter 2.4	Assignment 3 due Assignment 4 handed out
	• Minimum norm solutions with exact data • Continuous Inverse Problems	Chapter 3	Assignment 4 due Assignment 5 handed out
	• Rank • SVD • Rank Deficiency and Ill-Conditioning	Chapter 4	Assignment 5 due Assignment 6 handed out
	• Null space, uniqueness • Generalized Inverse	Chapter 4	Assignment 6 due Assignment 7 handed out
	• Tikhonov Regularization	Chapter 5	Midterm, no assignment
	Spring Recess No Class		
	• Iterative Methods, Conjugate Gradient	Chapter 6	Assignment 7 due Assignment 8 handed out
	• Other regularization techniques	Chapter 7/8	Assignment 8 due Assignment 9 handed out
	• Bayes Method • Bayesian Methods	Chapter 11	Assignment 9 due Assignment 10 handed out
	• Nonlinear Regression: • Gauss-Newton, Monte Carlo	Chapter 9	Assignment 10 due Assignment 11 handed out
	• Nonlinear Inverse Problems • Examples	Chapter 10	Assignment 11 due Assignment 12 handed out
	• Review		Assignment 12 due