

COURSE SYLLABUS

GEO 7600

Inverse Theory

Fall 2008

Lecture: TR 10:30—11:20

Professor: Tony Lowry (Department of Geology)
• Geology Bldg Room 106 (Phone: 797-7096)
• Email: Tony.Lowry@usu.edu
• Office Hours: 2:30—4:00pm MWF (or by appt)

COURSE DESCRIPTION

Inverse theory is a set of methods that we use to extract useful inferences about the world from physical measurements: a toolbox that enables us to pin our quantitative observations to an optimally parameterized model. Historically, inversion has been most heavily used in the field of geophysics, but truth-be-told **any** geological, geochemical or other type of measurement that can be quantified and modeled can also be inverted for a “best” answer.

Chances are, if you’ve ever done some sort of modeling or other data analysis, you probably have done at least some crude form of data inversion. A simple application of inverse theory is the fitting of data to a straight line. Tomographic imaging performed for a medical CAT scan is another, more sophisticated application. Often our measurements of the Earth are made far from the location of interest; typically they are also relatively few in number and noisy to boot. Consequently it is critical to understand not just what the “best” model is given some metric, but also the limitations of the data and the range of more-or-less equally possible solutions. Inverse theory enables us to characterize the certainty or uncertainty that we can ascribe to a particular model, the spatial or temporal resolution of our data, and the fundamental limits of what we can say from a particular dataset.

Not surprisingly, the tools we will discuss in this course are fundamentally mathematical. I make no apology for that, but note that we’ll be sticking to basic concepts of calculus, linear algebra and probability & statistics that should be familiar territory (and when they’re not, we’ll take it slow).

Ultimately, this course is meant to provide you (the student) with a set of tools and skills that will be helpful in both your current thesis research and your later career.

About the professor:

I am a geophysicist (“Physics of the Earth”) who focuses on measuring and understanding how and why planets deform. On Earth, this relates directly to processes of fault slip, earthquakes and volcanoes, but also has implications for mass transfer in the atmosphere, hydrosphere and cryosphere.

Course Text

(Required): **Geophysical Inverse Theory**, (Parker). (Recommended):
Geophysical Inverse Theory (Menke).

(VERY) TENTATIVE SCHEDULE

Date	Topic
26 Aug	Intro to Inverse Problems: How the model defines the problem
28 Aug	Probability & Statistics and Parameter Estimation
2 Sep	Linear Model Fits: Least Squares Solutions
4 Sep	Solution Appraisal
9 Sep	Data & Parameter Weighting
11 Sep	Choosing the Number of Parameters
16 Sep	Underdetermined Problems & Lagrange Multipliers
18 Sep	The Generalized Inverse
23 Sep	Damped Least Squares
25 Sep	Maximum Likelihood; L_1 and L_2 Norms
30 Sep	Nonlinear Model Fits: Linearizing Transformations
2 Oct	Gauss-Newton Method
7 Oct	Parameter Step Adjustment
9 Oct	Convergence
14 Oct	Solution Appraisal
16 Oct	No Class (Friday Schedule prior to Fall Break)
21 Oct	Grid and Random Search Methods
23 Oct	Solution Constraints: Equality constraints
28 Oct	Inequality Constraints (Linear Programming)
30 Oct	Inequality Constraints (Quadratic Programming)
4 Nov	Stochastic Inversion
6 Nov	No Class (Prof out of town)
11 Nov	Constrained Optimization (Nonlinear Problems)
13 Nov	Cooperative Inversion
18 Nov	Overparameterized Inversion
20 Nov	Bayesian Methods
25 Nov	(TBA)
27 Nov	(Thanksgiving Break)
2 Dec	(TBA)
4 Dec	(Possibly no class)
9 Dec (9:30am)	Course Projects

Web materials (incl. ppt's) and announcements will be available at

<http://anquetil.colorado.edu/~arlowry/Geo7600IT/index.html>

I am also trying out Blackboard Vista; stay tuned...

Grading:

Exercises	~3	30 pts
Semester Project		70 pts
Total		100 pts

Notice to veterans and students with disabilities: Students with ADA-documented physical, sensory, emotional or medical impairments may be eligible for reasonable accommodations. Veterans may also be eligible for services. All accommodations are coordinated through the Disability Resource Center (DRC) in Room 101 of the University Inn, (435) 797-2444 voice, (435) 797-0740 TTY, or toll free at 1-800-259-2966. Please contact the

DRC as early in the semester as possible. Alternate format materials (Braille, large print or digital) may be made available with advance notice.

University administrative dates:

Aug 31 - last day to add w/o signature of instructor

Sept 15 Last day to add classes; Last day to drop w/o notation (after this date, W is the course notation)

Nov 14 onward - No drops allowed

Dec 1-5 No test week