Spatial Statistics

http://www.isye.gatech.edu/ nserban/classes.html

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Office Hours: by appointment

Class Schedule

4:35 pm - 5:55 pm Tuesday and Thursday
No class: March 18 and 20 (Spring break)

Course Description

The course will cover methodology and case studies in spatial modeling, estimation and prediction with a focus on spatial-temporal processes, hierarchical frameworks in both Bayesian and frequentist formulations and spectral analysis of spatial processes. This course goes beyond standard practices and exposes the students to all the new developments and state of the art modern techniques for spatial data. All the methods presented will be introduced in the context of a specific dataset, then the motivation behind a particular method will be evident as it is developed. Computational skills will be highly needed as well as both statistical and mathematical knowledge will play an important role in understanding the concepts introduced in this course. The primary software package is 'R' but I advice you to look into other sources when working for your project.

Course prerequisites:

A sound familiarity with undergraduate and graduate statistics and probability.

Textbook:

The course material will be based on a set of notes being prepared by the instructor, but two primary textbooks are highly recommended:

1. Cressie (1993). *Statistics for Spatial Data*. Wiley & Sons.

2. Banerjee, Carlin and Gelfand (2004). *Hierarchical Modeling and Analysis for Spatial Data*. Chapman and Hall.

Other recommended books:

1. Stein (1999) *Interpolation of Spatial Data*. Springer. (very advanced; a good reference book for spatial statistics in the spectral domain)

2. Schabenberger and Gotway (2004). *Statistical Methods for Spatial Data Analysis*, Chapman & Hall. (a good reference at a moderate level; a good complement of Cressie's book)

3. Haining (2003), *Spatial Data Analysis: theory and practice*, Univerity Press, Cambridge. (not advanced statistics but very insightful; focused on economic applications)

Grading policy:

The course will be letter graded. The grade for the course will be based on 1. a final project that will be presented in class, 2. participation in class, 3. a computer-based assignment to be presented in class and 4. a discussion/presentation of one or two papers assigned throughout the course.
Project and presentation: 40%, Paper presentation 20%, Computer Lab presentation 30% and 10% class participation.

Project:
There will be a project, a spatial analysis using real data from the environmental, biomedical, geological and agricultural science selected by the student. The project may be also on a methodological topic in spatial statistics, which has not been covered in class. There will be an oral presentation of the project (15-20 minutes). Deadline to submit an abstract of the project: March 14, 2008. Deadline to submit the project work (report and presentation): April 18, 2008.

Reading Club:
As part of this course I would like you to get familiar and study current methodological developments in the literature of spatial statistics. Therefore, you will prepare a discussion on a publication from a list provided by the instructor or you may also choose a publication which is not included in this list at the instructor's approval. The discussion will be during class for 20 minutes followed by a 10 minutes session of questions. The discussant should give a formal presentation/discussion of the paper (with transparencies, using blackboard, or power point). All the papers will be available on the course web page. Each student will prepare two papers throughout the course.

Computer Lab Assignment:
The computer lab assignment consists of an analysis of datasets provided by the instructor related to a specific one-week lecture; this assignment requires preparation of the R or/and Matlab code and interpretation of the results including figures and software output. To fulfill this assignment, a student has to choose a specific topic included in the list of projected objectives and prepare to deliver its work within a one-lecture time frame. You may work in a group of two students.

Objectives:
This course will cover a number of areas of spatial statistics and data assimilation applied to real, scientific and interesting problems. A tentative list of more specific topics is as follows:

Part 1: Background and Motivation

1. Background: Types of Data, Taxonomies, Basic Properties, Preliminary Concepts (Spatial Structures and Modeling)
2. Motivation: Objectives and Applications
3. Challenges
4. Software

Part 2: Review of Types of Data with Applications

1. Point level models
2. Spatial point processes.
3. Areal (lattice) models

Part 3: Estimation and modeling of spatial correlations

1. Estimating variogram
2. Fitting parametric models: Matern class

3. Maximum likelihood estimation

4. restricted maximum likelihood

Part 4: Prediction and Kriging

1. Lagrange multiplier approach

2. Conditional inference approach

3. Predicting at multiple sites

4. Model misspecification in kriging

Part 5: Spatial-Temporal Models

1. Separable vs nonseparable models

2. Continuous time models when spatial dependence is nuisance

3. Spatial models when time dependence is nuisance

4. Misalignment (to be cont'd in Part 7)

5. Data integration (to be cont'd in Part 6 and 7)

Part 6: Bayesian spatial statistics

1. Bayesian estimation

2. Bayesian kriging

3. Bayesian priors for covariance parameters

4. Hierarchical Bayesian methods