STAT9100 : Recent Developments in Statistics: Point Processes and its applications
Spring Semester, 2015
Time: MWF 11:00-11:50
Location: MDLBH 10

Instructor: Athanasios Christou Micheas, Ph.D.
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Course Web Sites:
• Main: http://www.stat.missouri.edu/~amicheas/stat9100PP/index.html
• Computation and Simulation (basic methods here):
  http://www.stat.missouri.edu/~amicheas/stat301/stat301.html

Text:
• None. Use notes.

Some References:
• Statistics for Spatial Data, 1993, Noel A.C. Cressie, Wiley.

Prerequisites: Instructor’s Permission - Graduate Standing Required. Basic requirements: Stat7750/7760. Minimal measure theory used for the theoretical development; emphasis will be given in sampling algorithms and applications.

Topics to be covered:
• Point Process Theory: Introduction; Definitions and Properties
  1. Stationarity and consequences, Isotropic, Markov and Finite Point Processes
  2. Random Counting Measures
  3. Contact Distributions and Void Probabilities
  4. Moments and Moment Measures: The Intensity Measure; The Intensity Function; Second Order Measures
  5. Palm Distributions
• Poisson Point Process
  1. The Binomial Point Process
  2. The Poisson Point Process: Counting Variables; Construction of the Process; The Model Likelihood
  3. Parametric and Non-Parametric Estimation of the intensity function
4. Mixture modelling
5. The Bayesian Approach
6. Testing the Poisson Assumptions

• Gibbs Point Processes
• Spatial Birth-Death Processes
• Beyond the Poisson Process
  1. Construction of Models
  2. Operations on Point Processes; Thinning; Clustering; Other Operations
  3. Neyman-Scott Processes
  4. Hard-core Point Processes
  5. Cox processes
  6. Sampling Methods and Applications

• Marked Point Processes
  1. Definitions and Properties
  2. Conditioning on the Marks; Conditioning on the Spatial Locations
  3. Moments and Moment Measures; Palm Distributions

• The Marked Poisson Point Process
  1. Construction of the Process
  2. The Model Likelihood; Parametric and Non-Parametric Estimation of the Intensity Function
  3. Mixture modelling
  4. The Bayesian Approach
  5. The Boolean Model: Non-overlapping Random Disc Model; Hierarchical Bayesian formulation; Modelling difficulties and solutions; Boolean Model likelihood; The Poisson Boolean Model

• Spatial Temporal Point Processes: Definitions and Properties
  1. Formulation via Marked Point Processes
  2. Hierarchical Formulation of the Intensity Function: Conditioning on the Marks; Conditioning on the Spatial Location; Conditioning on the Time Component
  3. Moments and Moment Measures; Palm Distributions

• The Spatial Temporal Poisson Point Process
  1. Construction of the Process: The Model Likelihood; Parametric and Non-Parametric Estimation of the intensity function; Hierarchical Formulation
  2. Mixture modelling of the intensity function
  3. The Bayesian Approach

• Growth or Evolution models: The Poisson Boolean Model (time permitted)
  1. Non-overlapping Random Disc Model
  2. Hierarchical Bayesian formulation
  3. Modelling difficulties and solutions
Homework:

- There will be about five problem sets assigned during the semester.
- When submitting your homework:
  - Display clearly on the top of the first page: your name (last, first), the course name and section and the assignment number.
  - Homework should be done on standard-size paper (8 1/2" by 11").

Grading:

- Your grade will be based on your homework scores (10% each) and a final project (50%) that will be presented to the whole class.

- Cell Phones:

  It is your responsibility as a student of this university to have your cell phones, ipods, kindles etc CLOSED before entering the classroom. Using cell phones in class is not proper university conduct.

Course Description

Random variables and vectors have been extensively studied over the past two centuries. A natural generalization is to consider a random collection of points and consequently we need to analyze the underlying stochastic structure of point patterns formed by points that are distributed randomly in one, two or three dimensions. Analyses of such data sets require suitable mathematical models and appropriate statistical methods.

The area of mathematical research that seeks to provide such models and methods is called Point Process Theory. It is the study of random processes whose outcomes are random collections of points, that is, random countable subsets of \( \mathbb{R}^d \) or some given space.

In this class, we will discuss (spatial) point processes, and basic elements of point process theory. The highly applicable Poisson point process model will be treated extensively both from theoretical and application points of view, including the Boolean model and several growth or evolution models. We will discuss most known methods of simulation and computation of these random point patterns as well.