AMS 263: Stochastic Processes
Fall 2014

Instructor: Athanasios Kottas
Department of Applied Mathematics and Statistics
Office: 365A Baskin Engineering Building
Phone: 459-5536; E-mail: thanos@soe.ucsc.edu

Course web page: http://courses.soe.ucsc.edu/courses/ams263/Fall14/01

Lectures: Tuesday, Thursday 12-1:45pm (Social Sciences 2, Room 363)
Office hours: Wednesday 2-3pm (or by appointment)

Course description and background: This course provides a graduate level introduction to stochastic processes, including Markov processes, hidden Markov models, and point processes. Emphasis will be placed on theory and methods that provide useful background for stochastic modeling and statistical inference in stochastic processes. Although the development of the theory will be careful (especially for Markov chains), this course does not involve a rigorous measure-theoretic treatment of stochastic processes.

Knowledge of probability theory, distribution theory, and likelihood inference will be assumed. This background should be at least at the upper division undergraduate level (e.g., courses AMS 131/132), but preferably, at the graduate level (e.g., course AMS 205B). Useful, but not strictly required, background includes measure-theoretic probability (e.g., AMS 261) and Bayesian modeling and inference (e.g., AMS 206B/207).

Course grade: The course grade will be based on homework assignments and a project. Most of the homework problems will be on theory and methods from topics covered in class, but there will also be some problems on modeling and inference for data assumed to arise from particular classes of stochastic processes. The project will consist of expository review of a specific part of the relevant literature. The project topic can be on the theoretical side, expanding on the material covered in class. It may alternatively involve statistical modeling and inference methods for a class of stochastic processes, including illustration with appropriate data sets/case studies. The project topics will be chosen in collaboration with the instructor. A written project report will be required; moreover, there will be in-class project presentations. For the project presentations, we will likely use the day and time assigned by the registrar for the final exam: Wednesday December 17, 12-3 pm.
Course topics (tentative list)

1. Introduction
Basic concepts, definitions, and examples; Classification of stochastic processes; Finite dimensional distributions; Consistency conditions; Covariance and correlation functions; Weak and strong stationarity; Gaussian processes; Spectral theorem for (weakly) stationary processes; Ergodic theorem for stationary processes.

2. Markov chains
- Discrete-time, discrete-state Markov chains: Classification of states and chains; Stationary distributions and limit theorems; Reversibility; Ergodic theorem and its applications; Statistical inference for discrete-time Markov chains.
- Discrete-time, continuous-state Markov chains: Definitions and new concepts; Discussion of limit theorems, rates of convergence and the ergodic theorem; Applications of the theory to Markov chain Monte Carlo methods for Bayesian inference.
- Continuous-time Markov chains: Kolmogorov forward and backward equations; Stationary distributions; Birth-death processes; Statistical inference for continuous-time Markov chains.

3. Hidden Markov models
Discrete-time hidden Markov models; Likelihood recursions; Forward-backward recursions; Bayesian inference and forecasting under hidden Markov models; Continuous-time hidden Markov models; Markov modulated Poisson processes.

4. Point processes
The Poisson process and its generalizations; Spatial Poisson processes; Modeling and inference for Poisson processes; Cluster point processes; Marked point processes.

Reading/References: The lectures will be based on material taken from textbooks, research reference books, and journal papers. References on specific topics will be provided as needed. There is no required textbook. Relevant book references include: