NIMBioS Tutorial
Stochastic Models with Biological Applications

Wednesday, March 16, 2011
8:00-8:45 Breakfast at NIMBioS
8:45-9:00 NIMBioS Introduction
9:00-9:15 Introduction of Participants
9:15-10:45 Jie Xiong, “Introduction to Markov chains”
10:45-11:00 Break
11:00-12:30 Linda Allen, “Applications of discrete-time Markov chains and branching processes”
12:30-1:30 Lunch at NIMBioS
1:30-3:00 Linda Allen, “Applications of continuous-time Markov chains and branching processes”
3:00-3:15 Break
3:15-4:45 Jose Miguel Ponciano, “Parameter estimation for Markov chain models: fundamental concepts and computer intensive methods”
4:45-5:00 Break
5:00-6:00 Participant Computer Work: “Simulation of Markov chain models in biology”
6:00-8:00 Reception at NIMBioS

Thursday, March 17, 2011
8:00-8:45 Breakfast at NIMBioS
8:45-10:15 Jie Xiong, “Introduction to SDEs”
10:15-10:30 Break
10:30-12:00 Edward Allen, “Discrete-time stochastic models, SDEs, and numerical methods”
12:00-1:00 Lunch at NIMBioS
1:00-2:30 Jose Miguel Ponciano, “Parameter estimation for Markov chain models: computer intensive methods and current research challenges”
2:30-2:45 Break
2:45-4:15 Participant Computer Work: “Simulation of SDE models in biology”
4:15-4:30 Break
4:30-6:00 Discussion of problems of interest to participants
6:00-8:00 Dinner on Own

Friday, March 18, 2011
8:00-8:45 Breakfast at NIMBioS
8:45-10:15 Edward Allen, “Derivation of stochastic ordinary and partial differential equations”
10:15-10:30 Break
10:30-11:30 Informal discussions on computer work and problems of interest to participants
11:30-12:00 Closing remarks
12:00-1:00 Lunch at NIMBioS

Abstracts

Wednesday, March 16

Jie Xiong, "Introduction to Markov chains"
Abstract: Some basic definitions and notation for Markov chains will be introduced. Then, the state classification will be presented. Finally, some limit theorems will be established and the stationary distributions characterized.

Linda J. S. Allen, "Applications of discrete-time Markov chains and branching processes"
Abstract: Some classical biological applications of discrete-time Markov chain models and branching processes will be illustrated including a random walk model on a finite and semi-infinite domain, and logistic growth. Single-type and multitype branching processes applicable to population growth will be defined. Probability of population extinction, time to extinction, and the probability distribution conditioned on nonextinction will be illustrated in these examples.

Linda J. S. Allen, "Applications of continuous-time Markov chains and branching processes"
Abstract: Some applications of continuous-time Markov chains and branching processes will be illustrated including models for birth-death processes, cellular dynamics, and epidemics. The inter-event time and the Gillespie algorithm will be defined. The relationship between discrete-time and continuous-time processes will be illustrated in these examples. In addition, the probability of extinction, time to extinction, and the probability distribution conditioned on nonextinction will be discussed.

Jose Miguel Ponciano, "Parameter estimation for Markov chain models: fundamental statistical concepts and computer intensive methods"
Abstract: I will give a brief tutorial about maximum likelihood inference for discrete time and continuous time Markov chain models. Using a simple state-space model where all the calculations can be done by hand, I will illustrate the main concepts involved in parameter estimation for these models. Then, I will move on to illustrate the parameter estimation process using computer intensive methods, such as MCMC and other, recent developments requiring efficient simulation techniques for such stochastic processes.

Participant Computer Work: MatLaB computer programs on numerical methods for Markov chain models and parameter estimation methods.

Thursday, March 17

Jie Xiong, "Introduction to SDEs"
Abstract: The definition and some basic properties of Brownian motion will be introduced. Then, some properties of stochastic calculus will be presented and compared to the classic calculus. Finally, the basic theory of stochastic differential equations will be introduced.

Edward Allen, "Discrete-time stochastic models, SDEs, and numerical methods"
Abstract: A procedure is described for deriving a stochastic differential equation (SDE) from an

associated discrete stochastic model. Stochastic differential equation systems are derived for several population problems. (Modeling with SDEs continues in the second lecture.) Commonly used numerical procedures are described for computationally solving systems of stochastic differential equations.

Jose Miguel Ponciano, "Parameter estimation for Markov chain models: computer intensive methods and current research challenges"
Abstract: I will pick up on the topic of efficient simulation techniques for stochastic processes, do a full illustration of a study case involving a birth-death process and outline current, promising research avenues involving the interaction between stochastic processes modeling and modern statistical methods for Markov chains.

Participant Computer Work: MatLaB computer programs on numerical methods for SDEs.

Friday, March 18

Edward Allen, "Derivation of stochastic ordinary and partial differential equations"
Abstract: A procedure is reviewed for deriving a stochastic ordinary differential equation from an associated discrete stochastic model. Stochastic ordinary differential equation systems are derived for several population problems. Equivalence of stochastic differential equation systems is explained. It is shown how stochastic partial differential equation (SPDE) models can be derived. Several examples of SPDEs are presented.

Participant Questions and Hands-on Computer Work: Lecturers will help participants with computer work and answer questions on stochastic modeling.