Course Syllabus

Course Description

This course is meant to introduce the students to simulation, a statistical sampling technique that uses the power of computers to study complex stochastic systems when analytical or numerical techniques do not suffice. The course focuses on discrete-event simulation, a general technique used to analyze a model over time and determine the relevant quantities of interest.

Time and Place

Tuesday and Thursday 1:30–2:45. Room: Daniels 216.

Instructor

Yunan Liu
Office hours: 446 Daniels, right after class or by appointment
Email: *yunan_liu@ncsu.edu*
Phone: 919-513-7208
Homepage: *http://yunanliu.wordpress.ncsu.edu*

Teaching Assistant

TBD
Office hours: TBD Daniels, time TBD.
Email: *TA@ncsu.edu*

Textbooks

(i) S. M. Ross, *Simulation*. 5th Edition, Academic Press, 2014. (Required)

(ii) A. M. Law and W. D. Kelton, *Simulation Models and Analysis*. 3nd Edition, McGraw-Hill, 2000. (Recommended)

Prerequisites

This course is intended for graduate students in operations research and related fields. Student are expected to have completed a first course on stochastic models at the level of the first-year doctoral course ISE 760 and to have knowledge of a programming language such as MatLab.

Homework

There will be weekly assignments due every Tuesday in class. Graded assignments will be returned in class.

- Students are encouraged to collaborate with other students in the class, as long as each person writes his/her own solutions.
- But any such collaboration should be clearly **noted** (If some ideas of your solutions come from the discussion with another person, write his/her name on your solution).

- Copying homework from another student (past or present) is **forbidden**.
- Late homework will **NOT** be accepted.

Exams

All exams are closed book and notes. You are allowed to bring a two-sided cheat sheet.

- Midterm: TBD.
- Final: TBD.

Project

There will be a group project due close to the end of the semester that will have both modeling and coding components. Each group will be composed of two or three students and will be responsible for choosing a topic and submitting a project proposal before starting to work on the project; each project proposal must obtain the instructors approval. More information will be given in class regarding the potential topics and the requirements of the project.

Grading

Define the following random variables:
$HW \equiv$ homework, $M \equiv$ midterm, $F \equiv$ final exam, $P \equiv$ project and $G \equiv$ overall grade.
Then the overall grade is given by

$$G \equiv HW \times 20\% + M \times 30\% + P \times 20\% + F \times 30\%.$$

Tentative Course Topics

The course topics include:

1. Introduction to Simulation
   - Discrete event simulation
   - Monte Carlo simulation
2. Review of basic probability and statistics
   - Random variables and their properties
   - Estimation of means, variances, and correlations
   - The strong law of large numbers and central limit theorems
   - Confidence intervals and hypothesis tests for the mean
3. Random number generators and numerical integration
4. Generating copies of random variables
   - Inverse transform, Acceptance-Rejection, Composition

- Generating discrete random variables:
  (i) geometric; (ii) binomial; (iii) Poisson; (iv) negative binomial.
- Generating continuous random variables
  (i) exponential; (ii)uniform; (iii) Gaussian.
- Random permutations

5. Generating paths of stochastic processes

   - Poisson process: homogeneous, nonhomogeneous and compound
   - Continuous- and discrete-time Markov chains
   - Brownian motions

6. Simulation via discrete events

   - A single-server queueing system
   - A queueing system with two servers
   - An inventory model
   - An insurance risk model
   - A repair problem
   - Binary trees and Brownian Motion
   - Exercising a stock option

7. Output Data Analysis

   - Transient and steady-state behavior of a stochastic process
   - Statistical analysis for terminating simulations
   - Statistical analysis for steady-state parameters

8. Variance reduction techniques

   - Antithetic variables
   - Control variates
   - Variance reduction by conditioning
   - Stratified sampling
   - Importance sampling
   - Common random numbers

9. Selecting Input Probability Distributions

   - Sample independence
   - Hypothesizing families of distributions
   - Estimation of parameters
   - Goodness of fit tests