CS 661: Systems Simulation

Syllabus: Spring 2015

Course Info

- Class Logistics: Thursdays, 2:30 – 5:30pm at NJIT
- Instructor: Prof. Marvin K. Nakayama
- Office: GITC 4312
- Phone: 973-596-3398
- E-mail: `marvin@njit.edu` (be sure to include "CS 661" in the subject line)
- Office Hours: Wednesday, Thursday 1:00 – 2:00, and by appointment.
- Course Webpage: `http://web.njit.edu/~marvin/cs661`
  - username: `cs661`
  - password: `random`

Description

Simulation is one of the most widely used tools for analyzing complex processes and systems. Its use in business and engineering has increased dramatically in recent years, in part because of the increased power of personal computers and workstations, on which the vast majority of simulations are carried out. The uses of simulation in a business environment include evaluating alternative operational policies, viewing the impact of changes in personnel or equipment on business performance, assessing the capabilities of a proposed factory, performing risk analysis of a proposed business plan, and pricing financial instruments. Examples of the application of simulation in engineering include the design and analysis of computer systems, networking, web-based systems, and fault-tolerant computing.

This course covers the use of simulation as a tool for analyzing business and engineering problems. The two primary goals of the course are to learn how to plan, build and use simulation models and to develop an understanding of when simulation is an appropriate tool for analysis. Much of the work in the course involves learning the mathematical and software tools for building simulation models, performing experiments with them, and interpreting the results.

Although the focus of the course is on general simulation concepts and techniques, independent of a simulation package, we also illustrate some of the material using the software package ARENA, a popular simulation package. ARENA is well suited for creating large and detailed discrete-event simulation models. We also use Excel to carry out some Monte Carlo simulations.

Textbook

There is no required text for the course, but there are two optional texts:

- S. M. Ross, *Simulation*, 5th Edition, Academic Press, 2012, ISBN: 0124158250.
- P. Glasserman, *Monte Carlo Methods in Financial Engineering*, Springer, 2004, ISBN: 0387004513.

The Glasserman book is more appropriate for students in quantitative/mathematical finance. The Ross text covers simulation more generally and describes many applications in a broad range of fields.

Additional References

- S. Asmussen and P. W. Glynn, *Stochastic Simulation: Algorithms and Analysis*, Springer, 2007.
- J. Banks, J. S. Carson, B. L. Nelson, and D. M. Nicol, *Discrete-Event System Simulation*, 5th Ed., Prentice-Hall, 2009.
- P. Bratley, B. L. Fox, and L. E. Schage, *A Guide to Simulation*, 2nd Edition, Springer-Verlag, 1987.
- G. S. Fishman, *Monte Carlo: Concepts, Algorithms, and Applications*, Springer-Verlag, 1996.
- W. D. Kelton, R. P. Sadowski, and N. B. Swets, *Simulation with Arena*, 5th Edition, McGraw-Hill, 2010.
- A. M. Law, *Simulation Modeling and Analysis*, 5th Edition, McGraw-Hill, 2015.
- B. R. Ripley, *Stochastic Simulation*, Wiley, 2006.

Prerequisites

An undergraduate or graduate calculus-based course in probability and statistics at the level of Math 244 or Math 333, and basic knowledge of at least one higher-level programming language (e.g., C or Java).

Student Course Outcomes

The student course outcomes of the course are to

- Understand randomness and mathematical models of it.
- Understand how to build simulation models, including choices for input distributions and how to generate random objects.
- Understand how to design simulation experiments and analyze the output.
- Understand how to appropriately apply variance-reduction techniques.

Tentative Course Outline

1. Introduction to simulation modeling, and review of basic probability and statistics (2 weeks)
2. Probability distributions and input modeling (2 weeks)
3. Generating uniform and non-uniform random variates (2 weeks)
4. Fundamental simulation concepts (1 week)
5. Building simulation models using Arena (1 week)
6. Output data analysis for simulations (2 weeks)
7. Monte Carlo simulation, including project management and finance (2 weeks)
8. Variance-reduction techniques and optimization (2 weeks)

Throughout the course, we cover many topics in finance, including stochastic models for risky asset prices (geometric Brownian motion, jump-diffusion models, Markov regime-switching models), interest-rate models, portfolio valuation, pricing options (including exotic path-dependent options), estimating value-at-risk, and variance-reduction techniques for pricing path-dependent options.

Grading

Your final grade will be based on the following breakdown:

Class Participation/Attendance	10%
Assignments	20%
Midterm	35%
Final Exam	35%

If a student's homework scores are inconsistent with his or her exam scores, then the homework scores may be discounted in the weighting and the exam weights increased.

I may call on students at random during class, so class attendance is mandatory. **The tentative date of the midterm is March 12.** The final exam will be during the final-exam period at the time/date specified by the registrar. For all of the homework, you are to turn in written solutions at the beginning of class the day it is due. **Late homework will not be accepted.** The homeworks will not be carefully graded, but rather checked to see that students make a reasonable effort on all problems. If a student is caught cheating on the homework or exams, the student will be immediately reported to the dean of students.

Course Materials

You are **required** to download the course materials from the course web page. The materials, which include lecture notes and homework assignments, will be in pdf format. I will post lecture notes for a particular lecture at least 24 hours before the beginning of that class. Be sure to bring a printout of each day's lecture notes.

Software

Some of the homework assignments will involve developing simulation programs using the Arena simulation package. You can download Arena from a link on the course webpage. We will go over in class how to use Arena. You will need a PC running Windows to run Arena and you will need administrator privileges to install the software. Be sure to follow the installation instructions posted on the course webpage. Also, when installing the program, you should accept the default location. If you have an older version of Arena on your computer, you may need to uninstall it before installing the latest version. The uninstallation may require a CD of the previous version.

There may also be one assignment in which you will be given a program in C, and you will need to modify the program. Thus, you may need access to a C compiler; you can download one from `http://csd.njit.edu/software/`. (To access this software, you need to have an NJIT UCID. If you do not have a UCID, you can get one from `http://ist.njit.edu/accounts/ucid.php`.) A few other assignments will require a small amount of programming, which you can do (but are not required to) using Microsoft Excel and a free Excel add-in (link on course webpage).

Course Policies

Punctuality and class attendance is mandatory. If you cannot attend some class, you must contact me beforehand. **As a general rule, I do not give makeup exams or allow students to take exams on alternate dates.** I will allow absences for legitimate reasons (e.g., jury duty, serious medical problem, conflict with a religious holiday), but you must notify me before class and you must provide proper documentation (e.g., a note from your doctor) to the NJIT Dean of Students, who will inform me if your absence can be excused. I will not accept excuses such as having too heavy a workload or having too many exams the same week. **I also do not give out extra-credit assignments.**

Do not use any course materials from previous semesters. Any student caught using course materials from previous semesters will be reported to the dean of students.

Students are allowed to collaborate on assignments with others, but each student must write up and turn in his/her own solutions. Copying someone else's assignment is cheating, and any incidents will be reported to the dean of students.

Each HW assignment must be stapled together as a single document. If you don't do this, you will lose half the points on the assignment.

Requests for regrades of graded material (e.g., assignments or exams) must be requested within one week of when the graded item was first returned in class or when you were notified of your score, whichever is earlier. Any late regrade requests will not be considered.

Students will be notified of any modifications or deviations from the syllabus throughout the course of the semester.

Academic Integrity

Students must obey the NJIT University Code on Academic Integrity, which you can access from

`http://www.njit.edu/education/pdf/academic-integrity-code.pdf`

Any student caught violating this will be reported immediately to the Dean of Students. Violations include, but are not limited to,

- communicating with others during exams
- using unauthorized materials during exams

- copying/giving a computer program from/to another person.