

IIND 4117 – 2015II
Advanced Techniques in Computer Simulation
Course Syllabus

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Class hours: Tuesday and Thursday 3:30 to 4:50pm

Complementary class hour: Monday 3:30 to 4:50pm

Target Audience: Graduate students and advanced undergraduate students in engineering, mathematics and business.

Prerequisites:

Probability and Statistics II (IIND-2107) and a general purpose programming language (C, C++, Visual Basic, Java, Pascal, Fortran or equivalents). All prerequisites are necessary.

Course objectives:

- Develop the skills to build extensible simulation models on a high-level simulation language (Simio).
- Develop the ability to efficiently analyze and model input data.
- Develop the ability to perform advanced statistical analysis of output processes.
- Develop the skills to optimize the performance of a simulated system.
- Develop the skills to build flexible and efficient simulation models with a general-purpose (low-level) programming language.

Course Outline:

1. Review of probability and statistics (1 Week)
 - Simulation concepts and manual simulation
 - Descriptive statistics
 - Discrete and continuous distributions
 - Confidence intervals
 - Hypothesis testing
 - Histograms, q-q plots, p-p plots
 - Goodness of fit tests (Chi-Square, Kolmogorov-Smirnov)
 - Queueing theory
2. Discrete-event simulation with Simio (an introduction) (2 Weeks)
 - Simio modeling framework
 - Comparison with Arena
 - Fixed objects
 - Dynamic objects and movement
 - Working with model data
 - Extending model logic with processes
 - Building object definitions
 - Animation
 - Advanced topics
3. Stochastic modeling with simulation (1 Week)
 - Model design
 - Verification techniques
 - Validation techniques
 - Queueing models
 - Characteristics
 - Performance measures
 - Steady-state behavior
4. Statistical analysis of input data (2 Weeks)
 - Modeling input processes
 - Useful distribution families
 - Pearson distributions
 - Johnson translation system
 - Phase-type distributions
 - Shifted and truncated distributions
 - Bézier distributions
 - Specifying multivariate distributions, correlations and stochastic processes
 - Selecting a distribution in absence of data

- Models of arrival processes
 - Poisson processes
 - Non-stationary Poisson processes
 - Batch arrivals
 - Assessing homogeneity of different datasets
5. Random number generation (1 week)
- Linear congruential generators
 - Other kinds of generators
 - Testing random-number generators
 - Generating random variates
 - General approaches
 - Generating continuous and discrete random variates
 - Generating random vectors, correlated random vectors and stochastic processes
 - Generating arrival processes
6. Analyzing output processes (2 Weeks)
- Transient and steady-state behaviors
 - Output analysis for terminating simulations
 - Output analysis for steady-state parameters
 - Output analysis techniques for steady –state simulations
 - Replication analysis
 - Batch-means analysis
 - Regenerative analysis
 - Stopping rules
7. Variance reduction techniques (2 weeks)
- Common random numbers
 - Antithetic variates
 - Control variates
 - Indirect estimation
 - Conditioning
8. Continuous Simulation optimization (2 Weeks)
- Factorial designs
 - Response surface methods
 - Sensitivity and gradient estimation
 - Optimum seeking methods
9. Discrete-event simulation with (low-level) programming (2 Weeks)
- Rationale of computer simulation

- Event-oriented and process-oriented simulation
- Components of a simulation program
- Object-oriented simulation
- Illustrative examples
- SJJ Java library

Evaluation Method

• Exam 1	15%
• Exam 2	15%
• Exam 3	15%
• Project	25%
• Homework (x5)	25%
• Complementary	10%

Remarks

- In every complementary session, Simio modeling will be explored besides the class contents of the week.
- Homework assignments are to be done individually.
- Project is to be done in groups of two students, on the Simio Contest topic.
- The grades will be posted with two decimal digits of precision. For example, 2.99 is posted 2.99 with no round up.

References:Class contents

- Averill M. Law and David W. Kelton. Simulation Modeling and Analysis. McGraw-Hill Higher Education, 2000.
- Barry L. Nelson Stochastic Modeling Analysis & Simulation New York: McGraw-Hill, 2002.
- Garrido, José M. Object-Oriented Discrete-Event Simulation with Java: A Practical Introduction. New York: Kluwer Academic, 2001.
- Joines, J.A. and Roberts, S.D. Simulation Modeling With Simio: A Workbook, Simio Llc, 2010.
- Kelton, W. and Smith, J. and Sturrock, D. Simio and Simulation: Modeling, Analysis, Applications McGraw-Hill Higher Education, 2001.
- L'Ecuyer, P., Meliani, L. & Vaucher, JSSJ: A Framework for Stochastic Simulation in Java. E. Yücesan, C.-H. Chen, J. L. Snowdon, and J. M. Charnes (eds.). Proceedings of the 2002 Winter Simulation Conference. pp. 234-242.

- Schriber, T. and Brunner, D. T. Inside Discrete-Event Simulation Software: How it Works and Why it Matters. S. Andradóttir, K. J. Healy, D. H. Withers, and B. L. Nelson (eds.). Proceedings of the 1997 Winter Simulation Conference. pp. 14-22.
- Pegden, C. Dennis, Robert E. Shannon, and Randall P. Sadowski. Introduction to simulation using SIMAN. 2nd ed. New York: McGraw-Hill.1995.
- Proceedings of the Winter Simulation Conferences (to be assigned individually)

The following texts on Simio software package can be accessed from:

<http://www.simio.com/publications/>

- **Simulation Modeling with SIMIO: A Workbook**, “Authors [Jeffrey A. Joines](#) and [Stephen D. Roberts](#) invite you to turn on your computer, load Simio, and get ready to learn the simulation software with this "participatory style" workbook. This book expects your active participation in using Simio as you turn the pages.”
- **Introduction to Simio**, “This six-chapter PDF will get you started using Simio. Learn how Simio simulation software lets you build and run dynamic 3D animated models. Discover how to harness Simio's object approach to modeling to simulate systems such as factories, supply chains, emergency departments, airports, and service systems.”
- **The Simio Reference Guide**, “The free **Simio Reference Guide** provides a solid foundation for a Simio course. It is over 500 pages packed with information describing the user interface, how to get started, and how to do everything from building your first model to building complex objects. It even includes information on how an advanced user can add new features to the Simio product. This guide is included free in the Simio download and can be used in place of an expensive textbook.”