

SIMULATION AND MODELING

ENCT 353

Lecture : 3
Tutorial : 1
Practical : 3/2

Year : III
Part : II

Course Objectives:

The objective of this course is to develop knowledge of modeling and simulation techniques for discrete and continuous systems. It emphasizes the development and analysis of simulation models, generation and testing of random numbers and variables, and application of simulation methods to evaluate the performance of stochastic systems.

- 1 Introduction to Simulation (4 hours)**
 - 1.1 System and system environment concepts
 - 1.2 Continuous and discrete systems
 - 1.3 Types of models
 - 1.4 Model development life cycle
 - 1.5 Simulation and steps in simulation study
 - 1.6 Advantages and disadvantages of simulation
 - 1.7 Monte-Carlo simulation
 - 1.8 Discrete-event system simulation

- 2 Physical and Mathematical Models (4 hours)**
 - 2.1 Differential and partial differential equations
 - 2.2 Static physical model
 - 2.3 Dynamic physical model
 - 2.4 Static mathematical models
 - 2.5 Dynamic mathematical models

- 3 Simulation of Continuous System (5 hours)**
 - 3.1 Continuous system models
 - 3.2 Analog computer
 - 3.3 Analog methods
 - 3.4 Hybrid simulation
 - 3.5 Digital-analog simulators
 - 3.6 Continuous system simulation languages (CSSLs)
 - 3.7 Feedback systems

- 4 Simulation of Queuing System (6 hours)**
 - 4.1 Elements of queuing system

- 4.2 Characteristics of queuing systems
- 4.3 Model of queuing system
- 4.4 Types of queuing system
- 4.5 Queuing notation (Kendall's notation)
- 4.6 Measurement of system performance
- 4.7 Network of queues
- 4.8 Applications of queuing system

5 Markov Chains (3 hours)

- 5.1 Key features of Markov chains
- 5.2 Markov process with examples
- 5.3 Applications of Markov chains

6 Random Number (10 hours)

- 6.1 Properties of random numbers
- 6.2 Generation of pseudo-random numbers
- 6.3 Random number generation: Linear and arithmetic congruential methods
- 6.4 Tests for random numbers
 - 6.4.1 Kolmogorov-Smirnov test
 - 6.4.2 Chi-Square (χ^2) test
 - 6.4.3 Gap test
 - 6.4.4 Poker's method
 - 6.4.5 Testing for auto correlation
- 6.5 Generating discrete distribution
- 6.6 Inversion, rejection, composition and convolution

7 Verification and Validation of Simulation Models (3 hours)

- 7.1 Verification and validation
- 7.2 Verification of simulation models
- 7.3 Calibration and validation of models
- 7.4 Naylor and finger validation process
- 7.5 Validation: Errors

8 Analysis of simulation output (4 hours)

- 8.1 Confidence intervals and hypothesis testing
- 8.2 Estimation methods
- 8.3 Simulation run statistics
- 8.4 Replication of runs
- 8.5 Elimination of initial bias

9 Simulation software (3 hours)

- 9.1 Simulation in Java

- 9.2 Simulation in GPSS
- 9.3 Simulation in Python
- 9.4 Other simulation software

10 Simulation of Computer Systems

(3 hours)

- 10.1 Simulation tools
- 10.2 High level computer: System simulation
- 10.3 CPU simulation
- 10.4 Memory simulation
- 10.5 Simulation of computer networks

Tutorial

(15 hours)

- 1. Poisson process
- 2. Monte Carlo simulation
- 3. Queuing system and Markov chains
- 4. Different methods of random number generation
- 5. Kolmogorov-Smirnov test, Chi-square test, gap-test, poker and autocorrelation test
- 6. Modeling continuous and discrete systems
- 7. Simulation output analysis

Practical

(22.5 hours)

- 1. Simulation of the R-C amplifier circuit and mass spring damper system
- 2. Generation of random number
- 3. Chi-square goodness-of-fit test and Kolmogorov-Smirnov test
- 4. Simulation of queuing system
- 5. Simulation of Markov chain

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapters	Hours	Marks distribution*
1, 2	8	10
3	5	7
4	6	8
5	3	5
6	10	13
7	3	4
8	4	5
9, 10	6	8
Total	45	60

* There may be minor deviation in marks distribution.

References

1. Banks, J. (2005). Discrete-event system simulation. Pearson.
2. Gordon, G. (1978). System simulation (Latest Edition). Prentice Hall.
3. Law, A. M., Kelton, W. D. (2007). Simulation modeling and analysis. McGraw-Hill Education.
4. Rubinstein, R. Y., Melamed, B. (1998). Modern simulation and modeling (Latest Edition). John Wiley & Sons.
5. Singh, V. P. (2009). System modeling and simulation. New Age International Publishers.