Simulation in probability and statistics

Academic Year: (2021 / 2022) **Review date: 04/06/2021 14:15:53**

Department assigned to the subject: Statistics Department

Coordinating teacher: CASCOS FERNANDEZ, IGNACIO

Type: Compulsory ECTS Credits : 3.0

Year : 4 Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

All students in the Simulation course are expected to have completed the Probability course. It is highly advisable that they have also completed the courses on Statistics and Stochastic Processes.

OBJECTIVES

CG1.Students are able to demonstrate knowledge and understanding of concepts in mathematics, statistics and computation and to apply them to solve problems in science and engineering with an ability for analysis and synthesis.
CG4.Students are able to show that they can analyze and interpret, with help of computer science, the solutions obtained from problems associated to real world mathematical models, discriminating the most relevant behaviours for each application.
CG5.Students can synthesize conclusions obtained from analysis of mathematical models coming from real world applications and they can communicate in verbal and written form in English language, in an clear and convincing way and with a language that is accessible to the general public.
CG6.Students can search and use bibliographic resources, in physical or digital support, as they are needed to state and solve mathematically and computationally applied problems arising in new or unknown environments or with insufficient information.
CE1.Students have shown that they know and understand the mathematical language and abstract-rigorous reasoning as well as to apply them to state and prove precise results in several areas in mathematics.
CE8.Students are able to discretize mathematical models associated to real world problems using interpolation and approximation techniques, in order to solve them numerically by means of direct or iterative methods and to interpret the obtained solutions.
CE22.Students have shown that they understand the concept of random phenmena, and that they can apply the basic principles of probability calculus and the statistic inference, recognizing their applicability to real problems.
CE23.Students have shown that they understand the concepts of stochastic processes and queuing theory to model real world processes as well as to simulate them in a computer.
RA1.To have acquired sufficient knowledge and proved a sufficiently deep comprehension of the basic principles, both theoretical and practical, and methodology of the more important fields in science and technology as to be able to work successfully in them.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Random numbers (Monte Carlo tecniques)
1.1 Probability and inference refresher
1.2 Statistical validation techniques
1.3 (Pseudo)random number generation
1.4 Approximation of probabilities and volumes
1.5 Monte Carlo integration
2. Simulating random variables and vectors
2.1 Inverse transform
2.2 Aceptance-rejection
2.3 Composition approach
2.4 Multivariate distributions

2.5 Multivariate normal distribution
3. Discrete event simulation
3.1 Poisson processes
3.2 Gaussian processes
3.3 Single- and multi-server Queueing systems
3.4 Inventory model
3.5 Insurance risk model
3.6 Repair problem
3.7 Exercising a stock option
4. Efficiency improvement (variance reduction) techniques
4.1 Antithetic variables
4.2 Control variates
4.3 Stratified sampling
4.4 Importance sampling
5. MCMC
5.1 Markov chains
5.2 Metropolis-Hastings
5.3 Gibbs sampling
6. Introduction to the bootstrap
6.1 The bootstrap principle
6.2 Estimating standard errors
6.3 Parametric bootstrap
6.4 Bootstrap Confidence Intervals
6.5 Bootstrap Hypothesis Tests

LEARNING ACTIVITIES AND METHODOLOGY

- Lectures and problem sessions: introducing the theoretical concepts and developments with examples, and solving problems: 21 on-site hours
- Computer (practical) sessions: 4 on-site hours
- Homework: 49 non on-site hours
- Evaluation sessions (continuous evaluation and final exam): 5 on-site hours
- Specific exam preparation: 49 non on-site hours

ASSESSMENT SYSTEM

% end-of-term-examination/test:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

SE1.FINAL EXAM. Global assessment of knowledge, skills and capacities acquired throughout the course. The percentage of the evaluation will be 40% of the final grade.
SE2.CONTINUOUS EVALUATION. Assesses papers, projects, class presentations, debates, exercises, internships and workshops throughout the course. The percentage of the evaluation will be 60% of the final grade.

BASIC BIBLIOGRAPHY

- Christian P. Robert, George Casella Introducing Monte Carlo Methods with R, Springer, 2010

- Sheldon M. Ross Simulation, Academic Press, 2013 (5th ed)

ADDITIONAL BIBLIOGRAPHY

- Bradley Efron, Robert Tibshirani An introduction to the bootstrap, Chapman & Hall, 1993