Course guide
200608 - SIM - Simulation

Last modified: 01/06/2023

Unit in charge: School of Mathematics and Statistics
Teaching unit: 715 - EIO - Department of Statistics and Operations Research.
1004 - UB - (ENG)Universitat de Barcelona.

Degree: MASTER'S DEGREE IN STATISTICS AND OPERATIONS RESEARCH (Syllabus 2013). (Optional subject).

Academic year: 2023 **ECTS Credits:** 5.0 **Languages:** Spanish

LECTURER

Coordinating lecturer: ESTEVE CODINA SANCHO

Others: Primer quadrimestre:
SERGI CIVIT VIVES - A
ESTEVE CODINA SANCHO - A

PRIOR SKILLS

* Probability, statistical inference and Linear Models
* Some skills in a general purpose programming language, especially an scripting language. Familiarity with the R statistical software environment.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
4. CE-1. Ability to design and manage the collection of information and coding, handling, storing and processing it.
5. CE-2. Ability to master the proper terminology in a field that is necessary to apply statistical or operations research models and methods to solve real problems.
6. CE-3. Ability to formulate, analyze and validate models applicable to practical problems. Ability to select the method and / or statistical or operations research technique more appropriate to apply this model to the situation or problem.
7. CE-6. Ability to use appropriate software to perform the necessary calculations in solving a problem.
8. CE-8. Ability to discuss the validity, scope and relevance of these solutions and be able to present and defend their conclusions.

Transversal:
1. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding how companies are organised and the principles that govern their activity, and being able to understand employment regulations and the relationships between planning, industrial and commercial strategies, quality and profit.

2. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

3. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

TEACHING METHODOLOGY

-Theory and exercices
-Practical sessions
-Guided work

LEARNING OBJECTIVES OF THE SUBJECT

Students must acquire the main concepts and skills in Monte Carlo simulation as a tool to investigate statistical methods. Introduction to simulation as an Operation Research approach to work with systems models when a mathematical analytical approach is not available or unpractical. In depth knowledge of the model building process as a tool in decision-making. To obtain a panoramic view of the different approaches to systems simulation, and especifically a more in depth vision of discrete systems modeling. To acquire the main concepts and skills in the event-scheduling approach in simulation. Familiarise with the characterisation of stochasticity in modeling input data, random variate generation methods, simulation experimental design and simulation output data analysis.

STUDY LOAD

Type	Hours	Percentage
Self study	80,0	64.00
Hours small group	15,0	12.00
Hours large group	30,0	24.00

Total learning time: 125 h

CONTENTS

- Topic 1. Discrete System Models

Description:
Introduction to Simulation. Its use in Statistics and Operations Research. Basic use-cases. Continuous Time Markov Chais and Queues. Exponential and non-exponential queues. Batch queues, tandem and bloquing systems. Stages method.

Full-or-part-time: 25h
Theory classes: 7h
Laboratory classes: 3h 30m
Self study : 14h 30m

Topic 2. Input Data Analysis.

Description:
System analysis: data collection and knowledge acquisition processes. Randomness analysis. Descriptive analysis techniques. Probabilistic hypotheses formulation, simulation models adjustment and validation.

Full-or-part-time: 19h
Theory classes: 4h
Laboratory classes: 2h
Self study : 13h

Topic 3. Samples generation.

Description:
Pseudorandom sequences generation. General methods of discrete and continuous random variable generation. Generation of the main univariate distributions. Random vector generation. Stochastic processes generation.

Full-or-part-time: 22h
Theory classes: 5h
Laboratory classes: 2h 30m
Self study : 14h 30m

Topic 4. Introduction to discrete systems simulation.

Description:
Simulation models. Discrete and continuous simulation. Theoretic models for discrete system modeling: waiting systems. Stationarity. Little?s formula. Exponential models. GI/G/s models, approximations. System analysis: entities, attributes and relations identification. Simulation models formalization. Discrete systems simulation methodologies, "event-scheduling". Simulation of Markov Chains and Queues. Gillespie's method. Examples and applications.

Full-or-part-time: 24h
Theory classes: 6h
Laboratory classes: 3h
Self study : 15h

Topic 5. Statistical analysis of simulation experiments

Description:
Finite horizon simulations. Infinite horizon simulations: batch-means techniques, regenerative methods, etc. Variance reduction techniques. Design of simulation experiments.

Full-or-part-time: 10h
Theory classes: 3h
Laboratory classes: 1h
Self study : 6h

Topic 6. An introduction to the bootstrap and to permutation tests

Description:
Bootstrap, plug-in principle and simulation. Parametric and nonparametric bootstrap. Bootstrap confidence intervals. Permutation tests: exact and Montecarlo. Some permutation tests.

Full-or-part-time: 25h
Theory classes: 5h
Laboratory classes: 3h
Self study : 17h

GRADING SYSTEM

-1 midterm exam of topics 1 to 3. It is a qualifying exam.
-2 practical works, one of them centered on Simulation in Statistics, Bootstrap and Permutation tests, and the other on Systems Simulation.
-1 final exam, topics 4 and 6 in the case of midterm exam approval, topics 1 to 6 otherwise.

Let "E" be the exams grade (mean of midterm and final grades on the case of approved midterm; only final otherwise) and "T" the works grade. Then, the globar grade will be 0.5E + 0.5T.

EXAMINATION RULES.

Midterm exam is a qualifying exam: on approbation, no further examination of these topics is required.
Satisfactory delivering of ALL Practical Works is requested to pass.

BIBLIOGRAPHY

Basic:
- Efron, B.; Tibshirani, R. An Introduction to the bootstrap. Chapman & Hall, 1993. ISBN 0412042312.
- Good, Phillip I. Permutation, parametric and bootstrap tests of hypotheses [on line]. 3rd ed. New York, NY: Springer Science+Business Media, Inc, 2005 [Consultation: 05/07/2023]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/b138696. ISBN 9780387271583.
- Gentle, J.E. Elements of computational statistics [on line]. Springer, 2002 [Consultation: 05/07/2023]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/b97337. ISBN 0387954899.
- Banks, J. [et al.]. Discrete-event system simulation [on line]. Prentice Hall, 2005 [Consultation: 05/07/2023]. Available on: https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=5174427. ISBN 0132174499.
- Law, Av.M.; Kelton, W.D. Simulation modeling and analysis. 5th ed. McGraw-Hill, 2014. ISBN 1259254380.
- Fishman, G.S. Discrete-event simulation modeling, programming and analysis. Springer, 2001. ISBN 0387951601.
- Robert, C.P.; Casella, G. Monte Carlo statistical methods. 2nd ed. Springer, 2004. ISBN 0387212396.
- Ross, S.M. Simulation. 4a ed. Academic Press, 2006. ISBN 0125980639.
- Kroese, Dirk P.; Taimre, Thomas; Botev, Zdravko I. Handbook of Monte Carlo methods. New Jersey: John Wiley & Sons, 2011. ISBN 9780470177938.

RESOURCES

Other resources:
Campus virtual