

SYLLABUS

1. Information regarding the programme

1.1 Higher education institution	Babeş-Bolyai University
1.2 Faculty	Faculty of Mathematics and Computer Science
1.3 Department	Department of Computer Science
1.4 Field of study	Computer Science
1.5 Study cycle	Master
1.6 Study programme / Qualification	High Performance Computing and Big Data Analysis (Calcul de înaltă performanță și analiza volumelor mari de date)

2. Information regarding the discipline

2.1 Name of the discipline	Statistical Computational Methods						
2.2 Course coordinator	Prof. Sanda Micula, PhD. Habil.						
2.3 Seminar coordinator	Prof. Sanda Micula, PhD. Habil.						
2.4. Year of study	2	2.5 Semester	3	2.6. Type of evaluation	E	2.7 Type of discipline	DS Optional
2.8 Course Code	MME8088						

3. Total estimated time (hours/semester of didactic activities)

3.1 Hours per week	4	Of which: 3.2 course	2	3.3 seminar/laboratory	1S + 1P
3.4 Total hours in the curriculum	56	Of which: 3.5 course	28	3.6 seminar/laboratory	28
Time allotment:					hours
Learning using manual, course support, bibliography, course notes					35
Additional documentation (in libraries, on electronic platforms, field documentation)					15
Preparation for seminars/labs, homework, papers, portfolios and essays					32
Tutorship					14
Evaluations					23
Other activities:					-
3.7 Total individual study hours			119		
3.8 Total hours per semester			175		
3.9 Number of ECTS credits			7		

4. Prerequisites (if necessary)

4.1. curriculum	<ul style="list-style-type: none"> • Probability and Statistics
4.2. competencies	<ul style="list-style-type: none"> • Logical thinking • Average logical programming skills

5. Conditions (if necessary)

5.1. for the course	<ul style="list-style-type: none"> • Lecture room with large blackboard and video projector, laptop, beamer
5.2. for the seminar /lab	<ul style="list-style-type: none"> • For seminar: Laboratory with computers having Matlab installed

6. Specific competencies acquired

Professional competencies	C4.3 Identifying the appropriate models and methods for solving real-life problems C4.4 Using simulations in order to study and elaborate models and evaluate their performance
Transversal competencies	CT1 Ability to conform to the requirements of organized and efficient work, to develop a responsible approach towards the academic and scientific fields, in order to make the most of one's own creative potential, while obeying the rules and principles of professional ethic CT3 Using efficient methods and techniques for learning, information, research and developing capabilities for using knowledge, for adapting to a dynamic society and for communicating in Romanian and in a worldwide spoken language

7. Objectives of the discipline (outcome of the acquired competencies)

7.1 General objective of the discipline	<ul style="list-style-type: none"> Acquire basic knowledge of Probability Theory and Mathematical Statistics applications and models
7.2 Specific objective of the discipline	<ul style="list-style-type: none"> Ability to use Monte Carlo methods and simulations for solving real-life problems and perform statistical analysis of data Become familiar and be able to work with various probabilistic and statistical models Ability to use statistical features of various mathematical software

8. Content

8.1 Course	Teaching methods	Remarks
1. Review of Probability and Statistics. Probability space. Rules of probability. Conditional probability. Probabilistic models. Random variables and random vectors.	<ul style="list-style-type: none"> Interactive exposure Explanation Conversation Didactical demonstration 	
2. Common discrete and continuous distributions. PDF and CDF. Examples, applications, properties.	<ul style="list-style-type: none"> Interactive exposure Explanation Conversation Didactical demonstration 	
3. Random samples. Sample functions. Estimators. Confidence intervals. Hypothesis and significance testing.	<ul style="list-style-type: none"> Interactive exposure Explanation Conversation 	
4. Computer simulations and Monte Carlo methods. MC methods and random number generators. Discrete methods. Examples.	<ul style="list-style-type: none"> Interactive exposure Explanation Conversation Description 	
5. Inverse transform and discrete inverse transform method. Rejection method. Special methods. Examples.	<ul style="list-style-type: none"> Interactive exposure Explanation Conversation Didactical demonstration 	

6. Accuracy of an MC study. Estimating probabilities, means, variances. Size of an MC study. Other applications of MC methods.	<ul style="list-style-type: none"> • Interactive exposure • Explanation • Conversation • Didactical demonstration 	
7. Stochastic processes. Definitions, classifications. Markov processes and Markov chains. Transition probability matrix. Properties, examples.	<ul style="list-style-type: none"> • Interactive exposure • Explanation • Conversation • Description 	
8. Steady-state distribution. Regular Markov chains. Periodic Markov chains. Simulation of Markov chains.	<ul style="list-style-type: none"> • Interactive exposure • Explanation • Conversation • Didactical demonstration 	
9. Counting processes. Binomial and Poisson counting processes. Gamma-Poisson formula. Simulation of counting processes. Examples.	<ul style="list-style-type: none"> • Interactive exposure • Explanation • Conversation • Didactical demonstration 	
10. Queuing systems. Basic notions, main components, Little's law. Bernoulli single-server QS. Systems with limited capacity.	<ul style="list-style-type: none"> • Interactive exposure • Explanation • Conversation 	
11. M/M/1 QS. Evaluation of a system's performance. Examples.	<ul style="list-style-type: none"> • Interactive exposure • Explanation • Conversation • Didactical demonstration 	
12. Multiserver QS's. Bernoulli k-server and M/M/k QS's. M/M/∞ QS's. Simulation of QS's.	<ul style="list-style-type: none"> • Interactive exposure • Explanation • Conversation 	
13. Statistical inference. Nonparametric tests, Chi-square-tests, Wilcoxon tests. Bootstrapping. Applications, examples, simulations.	<ul style="list-style-type: none"> • Interactive exposure • Explanation • Conversation • Description 	
14. Regression and correlation. Fitting models. Analysis of variance (ANOVA), prediction. Examples.	<ul style="list-style-type: none"> • Interactive exposure • Explanation • Conversation • Didactical demonstration 	

Bibliography

1. Micula, S., Probability and Statistics for Computational Sciences, Cluj University Press, 2009.
2. Baron, M., Probability and Statistics for Computer Scientists, 3rd edition, CRC Press, Taylor and Francis, Boca Raton, FL, 2019.
3. Milton, J.S., Arnold, J. C., Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences, 3rd Edition. McGraw-Hill, New York, 1995.
4. Gentle, J. E., Elements of Computational Statistics, Springer-Verlag, New York, 2002.
5. Matloff, N., From Algorithms to Z-Scores: Probabilistic and Statistical Modelling in Computer Science, Orange Grove Texts Plus, Gainesville, FL, 2009.
6. Gentle, J. E., Hardle, W., Mori, Y., Handbook of Computational Statistics, Springer, Heidelberg, 2004.

8.2 Seminar /Laboratory	Teaching methods	Remarks
1. Random variables and applications.	<ul style="list-style-type: none"> • Interactive exposure • Explanation • Conversation 	The seminar is structured as 2 hours per week, every other week
2. Computer simulations of discrete random variables. Discrete methods.	<ul style="list-style-type: none"> • Interactive exposure • Explanation 	

	<ul style="list-style-type: none"> • Conversation • Individual and group work 	
3. Computer simulations of random variables and Monte Carlo studies. Inverse transform method, rejection method, special methods.	<ul style="list-style-type: none"> • Interactive exposure • Conversation • Synthesis • Individual and group work 	
4. Markov chains. Applications and simulations.	<ul style="list-style-type: none"> • Interactive exposure • Explanation • Conversation • Individual and group work 	
5. Counting processes. Bernoulli and Poisson counting processes. Applications and simulations.	<ul style="list-style-type: none"> • Interactive exposure • Explanation • Conversation • Individual and group work 	
6. Queuing systems. Examples and simulations.	<ul style="list-style-type: none"> • Interactive exposure • Explanation • Conversation • Individual and group work 	
7. Statistical inference. Applications and simulations. Lab test.	<ul style="list-style-type: none"> • Interactive exposure • Explanation • Conversation • Description • Individual and group work 	
Bibliography <ol style="list-style-type: none"> 1. Baron, M., Probability and Statistics for Computer Scientists, 3rd edition, CRC Press, Taylor and Francis, Boca Raton, FL, 2019. 2. Blaga, P., Statistica prin Matlab, Presa Universitara Clujeana, Cluj-Napoca, 2002. 3. Lisei, H., Micula, S., Soos, A., Probability Theory through Problems and Applications, Cluj University Press, 2006. 4. Milton, J.S., Arnold, J. C., Introduction to Probability and Statistics: Principles and Applications for Engineering and the Computing Sciences, 3rd Edition. McGraw-Hill, New York, 1995. 5. Gentle, J. E., Elements of Computational Statistics, Springer-Verlag, New York, 2002. 6. Matloff, N., From Algorithms to Z-Scores: Probabilistic and Statistical Modelling in Computer Science, Orange Grove Texts Plus, Gainesville, FL, 2009. 		

9. Corroborating the content of the discipline with the expectations of the epistemic community, professional associations and representative employers within the field of the program

<ul style="list-style-type: none"> • The course gives students solid statistical background for computational intelligence. • The knowledge and skills acquired in this course give students a foundation for launching a career in scientific research. • The statistical analysis abilities acquired in this course are useful in any career path students may choose.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Share in the grade (%)
10.4 Course	- acquire the basic principles in Computational Statistics, with emphasis on simulations and Monte Carlo studies; - be able to apply correctly the course concepts on various applications and problem solving	Written exam	70%
10.5 Seminar/Lab activities	- be able to apply course concepts and techniques on practical problems - be able to implement course concepts and algorithms in Matlab - be able to solve numerical statistical problems in Matlab	- participation in discussing, solving and implementing problems throughout the semester - individual presentation of solutions - lab test (numerical statistical applications and simulations)	30%
10.7 Minimum performance standards			
➤ A grade of 5 or above (on a scale from 1 to 10) on each activity mentioned above (written test, seminar/lab evaluation)			

Date

23.04.2024

Signature of course coordinator

Prof. Sanda Micula, PhD. Habil.

Signature of seminar coordinator

Prof. Sanda Micula, PhD. Habil.

Date of approval

Signature of the head of department

Prof. dr. Andrei Mărcuş