Linnæus University

Course syllabus

Faculty of Technology

Department of Mathematics

4MA506 Monte Carlo-metoder, 7.5 credits
Monte Carlo methods

Main field of study
Mathematics

Subject Group
Mathematics

Level of classification
Second Level

Progression
A1N

Date of Ratification
Approved 2015-05-22
Revised 2022-06-13 by Faculty of Technology. Examination and literature list are revised.
The course syllabus is valid from spring semester 2023

Prerequisites
1MA201/1MA501 Probability Theory and Statistics 7.5 credits or the equivalent course in Mathematical statistics, and 15 credits in mathematics at G2F-level.

Objectives
After successfully completing the course, the student is anticipated to be able to:

- explain the role of the Law of Large Numbers and the Central Limit Theorem for Monte Carlo methods
- account for general situations when Monte Carlo methods are needed.
- account for and write pseudocode for generation of discrete and continuous random variables by the inverse method, the acceptance-rejection method, and the composition method
- account for and write pseudocode for one-dimensional normal variables by the polar method
- account for and write pseudocodes for binomial random variables, Poisson random variables, homogenous and non-homogenous Poisson processes
- account for and write pseudocode for multidimensional normal variables
- account for and write pseudocode for variance reducting methods: antithetic

variables and control variates, conditioning, stratigic sampling, non-normalized and normalized importance sampling, latin cube hypercube sampling
- for a given simulation be able to suggest and implement a suitable variance reduction technique
- suggest and implement suitable statistical techniques to validate simulation models
- account for Markov Chain Monte Carlo methods and write pseudocode for the Hastings-Metropolis algorithm including Gibbs sampling.

Content

The course contains:

- General generation of one-dimensional random numbers, discrete and continuous: the inverse method, the acceptance-rejection technique, the compositon approach
- Generating specific one-dimensional random numbers: normal random numbers by the polar method, Poisson random variables, binomial random variables
- Generation of Poisson processes: homogenous and nonhomogenous, one-dimensional and two-dimensional
- Generation of multidimensional normal random numbers
- Generation of variables from copula models
- Variancereductiontechniques:useantitheticvariablesandcontrolvari- ates, conditioning, stratigic sampling, non-normalized and normalized importance sampling, latin hypercube sampling
- Statistical analysis of simulated data: the sample mean and sample variance, interval estimates of a population mean, bootstrapping technique for estimating mean square errors
- Statistical validation techniques: goodness of fit tests
- Markov Chain Monte Carlo methods: Hastings-Metropolis algorithm including Gibbs sampling

Type of Instruction

Teaching consists of lectures, presentations,and tutoring.

Examination

The course is assessed with the grades A, B, C, D, E, Fx or F.

The grade A constitutes the highest grade on the scale and the remaining grades follow in descending order where the grade E is the lowest grade on the scale that will result in a pass. The grade F means that the student’s performance is assessed as fail (i.e. received the grade F).

The student's knowledge is assessed in form of
1. Graded written assignments (4 p), grading scale A-F
2. Written report of a project (1.5 hp), grading scale A-F
3. Oral presentation of a project (1.5 hp), grading scale A-F
4. Opposition of a another student's project (0.5 hp), grading scale U/G
The final grade of the course is decided as an weighted average of the grades for the assessments 1, 2, and 3 above.

Repeat examination is offered in accordance with Local regulations for courses and examination at the first and second-cycle level at Linnaeus University.If the university has decided that a student is entitled to special pedagogical support due to a disability, the examiner has the right to give a customised exam or to have the student conduct the exam in an alternative way.

Course Evaluation

During the implementation of the course or in close conjunction with the course, a course evaluation is to be carried out. Results and analysis of the course evaluation are to be promptly presented as feedback to the students who have completed the course. Students who participate during the next course instance receive feedback at the start of the course. The course evaluation is to be carried out anonymously.

Credit Overlap

The course cannot be included in a degree along with the following course/courses of which the content fully, or partly, corresponds to the content of this course: 4MA206 Monte Carlo methods, 7.5 credits

Other

Grade criteria for the A–F scale are communicated to the student through a special document. The student is to be informed about the grade criteria for the course by the start of the course at the latest.

Required Reading and Additional Study Material

Required reading
Sheldon M. Ross: *Simulation*, latest edition, Academic Press Inc

Reference Literature
Asmussen, Søren & Glynn, Peter: *Stochastic simulation: algorithms and analysis*, Springer, latest edition.

Fishman, George S: *Monte Carlo: Concepts, algorithms, and applications*, Springer, latest edition.

Glasserman, Paul: *Monte Carlo methods in financial engineering*, Springer, latest edition.