Allievi Program in Economics, Statistics and Applied Mathematics

MODELS AND ALGORITHMS

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Contact Information

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Introduction

This course provides a hands-on introduction to the use of Monte Carlo methods in the analysis of probabilistic models and related algorithms for the approximate solution of sampling, optimization, and inference problems. The course will contain both theoretical lectures and computational tutorial sessions, which will involve the implementation on a computer of the algorithms under study. Tutorial sessions will make use of open-source softwares for interactive computing, such as Jupyter notebooks, and Python (or Julia, if preferred by the students) will be adopted as common programming language for any practical implementation.

Course Topics

- Introduction to Python (or Julia) programming language.

- Direct Monte Carlo methods: uniform MC sampling, rejection sampling, importance sampling.
- Markov Chain Monte Carlo methods: review of Markov chains, theory of MCMC sampling, Metropolis-Hastings algorithm, issues and improvements of MCMC algorithms.
- Applications to optimization problems (Simulated Annealing), sampling of continuous-time Markov processes (Stochastic Simulation Algorithm), and parameter inference in probabilistic models (MC inference methods, Approximate Bayesian Computation).

Prerequisites

Basic knowledge of calculus and probability theory is required, but the course is designed to be as self-contained as possible. During the course, some advanced theoretical results in probability theory and stochastic processes will be introduced with particular attention to their practical and computational application. If needed, additional reading material will be provided for individual study. Prior knowledge of the Python/Julia programming language is welcome but not required.

Evaluation

The final evaluation will be performed based on an individual assignment, which will require applying theoretical concepts and algorithmic techniques learned during the course to the solution of a specific computational problem. Students are encouraged to work in groups on such final assignment, but they have to eventually submit it individually, in the form of a Jupyter notebook containing both the code for the implementation of the algorithmic parts and comments in which both the methods and the results obtained are discussed. Students will be then individually interviewed on the content of their project by means of a brief oral exam. The final grade will be a combination of the evaluation of the project (75%) and the evaluation of the oral exam (25%).

Textbooks

Lecture notes will be provided during the course as well as the Jupyter notebooks used in the tutorials and additional reading material.