COM-516

Markov chains and algorithmic applications

Cursus	Sem.	Type
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Opt.
Electrical Engineering		Opt.
SC master EPFL	MA1, MA3	Opt.

Language of teaching	English
Credits	6
Session	Winter
Semester	Fall
Exam	Written
Workload	180h
Weeks	14
Hours	**4 weekly**
Courses	2 weekly
Exercises	1 weekly
Lab	1 weekly
Number of positions	

Remark

Pas donné en 2026-27 - Cours biennal

Summary

The study of random walks finds many applications in computer science and communications. The goal of the course is to get familiar with the theory of random walks, and to get an overview of some applications of this theory to problems of interest in communications, computer and network science.

Content

Part 1: Markov chains (~6 weeks):
- basic properties: irreducibility, periodicity, recurrence/transience, stationary and limiting distributions,
- ergodic theorem: coupling method
- detailed balance
- convergence rate to the equilibrium, spectral gap, mixing times
- cutoff phenomenon

Part 2: Sampling (~6 weeks)
- classical methods, importance and rejection sampling
- Markov Chain Monte Carlo methods, Metropolis-Hastings algorithm, Glauber dynamics, Gibbs sampling
- applications: function minimization, coloring problem, satisfiability problems, Ising models
- coupling from the past and exact simulation

Keywords

random walks, stationarity, ergodic, convergence, spectral gap, mixing time, sampling, Markov chain Monte Carlo, coupling from the past

Learning Prerequisites

Required courses

Basic probability course
Basic linear algebra and calculus courses

Recommended courses

Stochastic Models for Communications (COM-300)

Important concepts to start the course

Good knowledge of probability and analysis.
Having been exposed to the theory of Markov chains.

Learning Outcomes

By the end of the course, the student must be able to:

- Analyze the behaviour of a random walk
- Assess / Evaluate the performance of an algorithm on a graph
- Implement efficiently various sampling methods

Teaching methods

ex-cathedra course

Expected student activities

active participation to exercise sessions and implementation of a sampling algorithm

Assessment methods

- midterm
- mini-project
- final exam

Resources

Bibliography

Various references will be given to the students during the course, according to the topics discussed in class.

Ressources en bibliothèque

- Probability and random processes / Grimmett

Notes/Handbook

Lecture notes will be provided

Websites

- https://moodle.epfl.ch/course/view.php?id=15016

Moodle Link

- https://go.epfl.ch/COM-516

Prerequisite for

This course is not so to speak a prerequisite for other courses, but could complement well the course COM-512 on Networks out of control, as well as other courses in statistics.