CS-435 **Analytic algorithms**

Cursus	Sem.	Type
Computer science	MA2	Opt.
Data Science	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Session	Summer
Semester	Spring
Exam	During the semester
Workload	120h
Weeks	14
Hours	**3 weekly**
Courses	2 weekly
Exercises	1 weekly
Number of positions	

Remark

pas donné en 2018-19

Summary

In the last decade, many fundamental algorithmic problems have benefited from viewing the underlying discrete problems through the lens of continuous/analytic methods. In this course we will introduce a selection of such techniques and explore their applications.

Content

Convexity and gradient descent
Multiplicative weight update (MWU) method and online convex optimization
Gradient descent based methods for solving linear equations
Optimization problems involving polynomials
Graphs and their eigenvectors and eigenvalues
Graphs as electrical networks
Graphs Laplacians and solving Laplacian equations
Application: Fast algorithms to compute network flows (using MWU, electrical flows and Laplacian solvers)
Application: Fast algorithms for graph cuts (using eigenvectors and Laplacian solvers)
Application: Algorithms for counting perfect matchings in graphs (using convex programs involving polynomials)

Keywords

Convex optimization, Spectral methods, Polynomials, Discrete Optimization, Continuous Optimization

Learning Prerequisites

Required courses

Calculus (MATH105), Linear Algebra (MATH111), Algorithms (CS250), Theory of Computation (CS251) or equivalents, Advanced Algorithms (CS-450) (or equivalent).

Recommended courses

Important concepts to start the course

This is an advanced course and requires mathematical maturity including linear algebra, multi-variate

calculus, analysis, probability and algorithms.

Learning Outcomes

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

- Learn fundamental techniques which apply continuous methods to discrete problems
- Apply analytic techniques to a variety of related problems
- Read, understand, and explain state of the art papers in this area

Assessment methods

Homeworks, Scribe Notes, Exam and Project/Presentation*.
*Tentative

Resources

Bibliography

Books relevant to the course:
Vishnoi - Lx=b
Nesterov - Introductory lectures on convex optimization
Shalev-Schwartz - Online learning and online convex optimization
References for Basics:
Apostol - Calculus I and II
Strang - Linear algebra and its applications
Boyd and Vanderberghe - Convex optimization
Strogatz - Nonlinear dynamics and Chaos

Ressources en bibliothèque

- Lx=b / Vishnoi (print)
- Lx=b / Vishnoi (online)
- Introductory lectures on convex optimization / Nesterov
- Online learning and online convex optimization / Shalev-Schwartz
- Nonlinear dynamics and Chaos / Strogatz
- Calculus II / Apostol
- Linear algebra and its applications / Strang
- Convex optimization / Boyd
- Calculus I / Apostol

Notes/Handbook

Vishnoi - Zeros of Polynomials and their Applications to theory. Available from http://theory.epfl.ch/vishnoi/Publications_files/ZerosIntro.pdf

Vishnoi -- A mini-course on convex optimization. Available from http://theory.epfl.ch/vishnoi/Nisheeth-VishnoiFall2014-ConvexOptimization.pdf