

CS-435

Analytic algorithms

Vishnoi Nisheeth

Cursus	Sem.	Type
Computer science	MA2	Opt.
Data Science	MA2	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	

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 (MATH110), 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](#)
- [Calculus I / Apostol](#)
- [Calculus II / Apostol](#)
- [Linear algebra and its applications / Strang](#)
- [Convex optimization / Boyd](#)
- [Nonlinear dynamics and Chaos / Strogatz](#)

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>