EPFL

MGT-418

Convex optimization

Kuhn Daniel

Cursus	Sem.	Type
Electrical and Electronical Engineering	MA1, MA3	Obl.
Energy Science and Technology	MA1, MA3	Obl.
Management of technology		Opt.
Management, Technology and Entrepreneurship minor	H	Opt.
Managmt, tech et entr.	MA1, MA3	Opt.
Mechanical engineering	MA1, MA3	Opt.
Robotics, Control and Intelligent Systems		Opt.
Robotics	MA1, MA3	Opt.
Statistics	MA1, MA3	Opt.

Language of teaching	English
Credits	5
Session	Winter
Semester	Fall
Exam	Written
Workload	150h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

This course introduces the theory and application of modern convex optimization from an engineering perspective.

Content

Convex optimization is a fundamental branch of **applied mathematics** that has applications in almost all areas of **engineering**, the **basic sciences** and **economics**. For example, it is not possible to fully understand support vector machines in statistical learning, nodal pricing in electricity markets, the fundamental welfare theorems in economics, or Nash equilibria in two-player zero-sum games without understanding the duality theory of convex optimization.
The course primarily focuses on techniques for **formulating** decision problems as convex optimization models that can be solved with **existing software tools**. The exact formulation of an optimization model often determines whether the model can be solved within seconds or only within days, and whether it can be solved for ten variables or up to 10^6 variables. The course does not address optimization algorithms but covers the theory that is necessary to follow advanced courses on algorithm design such as EE-556: Mathematics of data: from theory to computation.

Tentative Course Outline:
Week 1: Introduction / Convex Sets
Week 2: Convex Sets / Convex Functions
Week 3: Convex Functions / Convex Optimization Problems
Week 4: Convex Optimization Problems
Week 5: Introduction to Duality Theory
Week 6: Optimality Conditions / Separation Theorems
Week 7: Strong Duality
Week 8: Optimization in Statistics and Machine Learning
Week 9: Optimization in Statistics and Machine Learning
Week 10: Convexifying Nonconvex Problems
Week 11: Convexifying Nonconvex Problems
Week 12: Robust Optimization
Week 13: Robust Optimization
Week 14: Stochastic Programming

Learning Prerequisites

Required courses

Students are assumed to have good knowledge of linear algebra and analysis.

Important concepts to start the course

Some familiarity with linear programming or other optimization paradigms is useful but not necessary.
Students are expected to be familiar with PYTHON.

Learning Outcomes

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

- Model and solve decision problems affected by uncertainty
- Formalize decision problems in engineering and economics as mathematical optimization models
- Solve the resulting models with off-the-shelf optimization software and interpret the results
- Assess / Evaluate the computational complexity of different classes of optimization problems and use modeling techniques to make specific optimization problems more tractable

Transversal skills

- Communicate effectively with professionals from other disciplines.
- Use both general and domain specific IT resources and tools
- Assess one's own level of skill acquisition, and plan their on-going learning goals.
- Write a scientific or technical report.

Teaching methods

Classical formal teaching interlaced with practical exercices and computational courseworks.

Assessment methods

30% Midterm exam
20% Computational projects
50% Final exam

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Bibliography

- Stephen Boyd and Lieven Vandenberghe, Convex Optimization, Cambridge University Press, 2004
- Aharon Ben-Tal and Arkadi Nemirovski, Lectures on Modern Convex Optimization, SIAM, 2001
- Yurii Nesterov, Introductory Lectures on Convex Optimization: A Basic Course, Springer, 2004
- David Luenberger and Yinyu Ye, Linear and Nonlinear Programming, Springer, 2008
- R. Tyrrell Rockafellar, Conjugate Duality and Optimization, SIAM, 1974
- Joshua A. Taylor, Convex Optimization of Power Systems, Cambridge University Press, 2015

Ressources en bibliothèque

- Convex Optimization / Boyd
- Conjugate Duality and Optimization / Rockafellar
- Lectures on Modern Convex Optimization / Ben-Tal
- Linear and Nonlinear Programming / Luenberger
- Introductory Lectures on Convex Optimization: A Basic Course / Nesterov
- Convex Optimization of Power Systems / Taylor

Moodle Link

- https://go.epfl.ch/MGT-418