Optimization

Code: 40999
PhD in Statistics & Computer Science, Bocconi University
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Objectives

This course covers some theoretical aspects of mathematical optimization, with a particular focus on convex optimization. Many classes of convex optimization problems admit efficient algorithms, whereas mathematical optimization is in general computationally intractable. The course will have a computational viewpoint, with emphasis on foundations and rigorous results. The course will provide tools and ideas which have been extremely useful in algorithm design, and to solve large-scale Machine Learning problems. The goal of the course is developing a solid understanding of the structure and properties of optimization problems, and a firm knowledge of a modern algorithmic toolbox containing practical and provably efficient numerical methods.

Syllabus

- Review of some basic notions: convexity, first-order optimality conditions, projections
- Separation & theorems of the alternatives
- Intro to linear optimization: duality theory and the simplex algorithm
- Lagrangian duality & KKT conditions
- Ellipsoid algorithm. Equivalence between separation and optimization
- First-order methods: (stochastic) gradient descent & mirror descent
- Interior-point methods
- Intro to online convex optimization: online mirror descent and FTRL
- Overview of stochastic and adversarial multi-armed bandits algorithms
- Blackwell approachability and applications to equilibrium computation problems

Textbooks

During the course I may draw on the following resources:

- Jean-Baptiste Hiriart-Urruty and Claude Lemaréchal. *Fundamentals of convex analysis*. Springer Science & Business Media, 2004
- Dimitris Bertsimas and John N Tsitsiklis. *Introduction to linear optimization*, volume 6. Athena Scientific Belmont, MA, 1997
- Stephen Boyd and Lieven Vandenberghe. *Convex optimization*. Cambridge university press, 2004
- Aharon Ben-Tal and Arkadi Nemirovski. *Lectures on modern convex optimization: analysis, algorithms, and engineering applications*. SIAM, 2001
- Sébastien Bubeck et al. Convex optimization: Algorithms and complexity. *Foundations and Trends® in Machine Learning*, 8(3-4):231–357, 2015
- Nicolo Cesa-Bianchi and Gábor Lugosi. *Prediction, learning, and games*. Cambridge university press, 2006

Exam

Take home problem sets and final oral exam consisting of a critical discussion of a research paper.