MATH 6366-24238 (Fall 2010): Optimization I *

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Texts

Convex Optimization, Stephen Boyd and Lieven Vandenberghe, Cambridge University Press, 2004
(available on the web at http://www.stanford.edu/˜boyd/cvxbook.html)

Objectives

The focus is on key topics in optimization that are connected through the themes of convexity, Lagrange multipliers, and duality. The aim is to develop a analytical treatment of finite dimensional constrained optimization, duality, and saddle point theory, using a few of unifying principles that can be easily visualized and readily understood. The course is divided into three parts that deal with convex analysis, optimality conditions and duality, computational techniques. In Part I, the mathematical theory of convex sets and functions is developed, which allows an intuitive, geometrical approach to the subject of duality and saddle point theory. This theory is developed in detail in Part II and in parallel with other convex optimization topics. In Part III, a comprehensive and up-to-date description of the most effective algorithms is given along with convergence analysis.

*This syllabus contains important information about this course to which you will need to refer from time to time.

Remarks

This is the first semester of a two-semester course. The focus in this semester will be on convex optimization.

Prerequisites

Graduate standing or consent of the instructor. Students are expected to have a good grounding in basic real analysis and linear algebra.

Course Policies and Procedures

Grades: Homework (50 percent), Exams (50 percent)

Exams: There will be two exams, one in-class midterm (3/4 hour) and one take-home final (3 days over a weekend). No make-up exams will be given.

Homework: There are total six homework assignments. You may, with impunity, submit up to two assignments up to one class period (not one week) beyond their due date. Subsequent submissions will incur penalties in increments of 10%. Homework submitted later than one class period beyond its due date will not be accepted without a written excuse. Homework scores can not be changed one week after they have been returned.

Honor Code Policy: You are encouraged to discuss homework with your classmates. However, you are expected to individually write up your solutions.

Course Outline, Homework and Exam Dates[1]

- **Introduction**
  - Week 1 (Aug. 23 - 27) Mathematical optimization, Least-squares and linear programming, Convex optimization
- **Part I Convex Sets**
  - Week 2 (Aug. 30 - Sept. 3) Affine and convex sets, Some important examples, Operations that preserve convexity
  - Week 3 (Sept. 8 - 10) Generalized inequalities, Separating and supporting hyperplanes, Dual cones and generalized inequalities
- Assignment I (Sept. 13) 2.2, 2.9, 2.10(a), 2.12, 2.15, 2.28.
- **Part II Convex Functions**
  - Week 4 (Sept. 13 - 17) Basic properties and examples, Operations that preserve convexity, The conjugate function
  - Week 5 (Sept. 20 - 24) Quasiconvex functions, Log-concave and log-convex functions, Convexity with respect to generalized inequalities
- Assignment II (Sept. 27) 3.2, 3.5, 3.16, 3.24, 3.36(a), 3.42, 3.49(a).
- **Part III Convex Optimization Problems**
  - Week 6 (Sept. 27 - Oct. 1) Optimization problems, Convex optimization, Linear optimization problems
  - Week 7 (Oct. 4 - 8) Quadratic optimization problems, Geometric programming, Generalized inequality constraints
- Assignment III (Oct. 11) 4.2, 4.5, 4.8, 4.11, 4.15, 4.22.
- **Part IV Duality**
  - Week 8 (Oct. 11 - 15) The Lagrange dual function, The Lagrange dual problem, Geometric interpretation, Saddle-point interpretation
  - Week 9 (Oct. 18 - 22) Optimality conditions, Perturbation and sensitivity analysis, Examples.
- Assignment IV (Oct. 25) 5.1, 5.3, 5.5, 5.11, 5.13, 5.27

[1] This schedule, including dates of exams, is subject to change. Changes will be announced in class.

- **In-Class Midterm (Oct. 22)**
- **Part V Unconstrained and Equality Constrained Minimizations**
  - Week 10 (Oct. 25 - 29) Unconstrained minimization problems, Gradient and Steepest descent methods, Newton's method
  - Week 11 (Nov. 1 - 5) Self-concordance, Implementation, Equality constrained minimization problems
  - Week 12 (Nov. 8 - 12) Newton's method with equality constraints, Infeasible start Newton method, Implementation
- Assignment IV (Nov. 15) 9.1, 9.12, 10.1, 10.3, 10.9, 10.11
- **Part VI Interior-Point Methods**
  - Week 13-14 (Nov. 15 - 22) Inequality constrained minimization problems, Logarithmic barrier function and central path, The barrier method, Feasibility and phase I methods
  - Week 15 (Nov. 29 - Dec. 3) Complexity analysis via self-concordance, Primal-dual interior-point methods, Implementation
- Assignment IV (Dec. 3) 11.3, 11.6, 11.9, 11.11
- **Take-Home Final (Dec. 3-6)**