CSE203B Convex Optimization

CK Cheng
Dept. of Computer Science and Engineering
University of California, San Diego
Outlines

• Staff
  – Instructor: CK Cheng
  – TAs: Po-Ya Hsu, Chester Holtz, James Lin

• Logistics
  – Websites, Textbooks, References, Grading Policy

• Classification
  – History and Category

• Scope
  – Coverage
Information about the Instructor

- Instructor: CK Cheng
- Education: Ph.D. in EECS UC Berkeley
- Industrial Experiences: Engineer of AMD, Mentor Graphics, Bellcore; Consultant for technology companies
- Research: Design Automation, Brain Computer Interface
- Email: ckcheng+203B@ucsd.edu, Office: Room CSE2130
- Office hour will be posted on the course website
- Websites
  - http://cseweb.ucsd.edu/~kuan
  - http://cseweb.ucsd.edu/classes/wi21/cse203B
Staff

Teaching Assistant

• Po-Ya Hsu, p8hsu@ucsd.edu
• Chester Holtz, chholtz@ucsd.edu
• James Lin, til002@ucsd.edu
Logistics: Class Schedule

Class Time: 2-320 PM TTH,
Discussion Session: 2-250 PM F (Separate zoom link)
Class website: http://cseweb.ucsd.edu/classes/wi21/cse203B
Piazza link: piazza.com/ucsd/winter2021/cse203b/home
Gradescope link: https://www.gradescope.com/courses/221286
Zoom lecture: https://ucsd.zoom.us/j/98033436384?pwd=Y3UrMDIiY0pyOTRmTGovVENQSXpvdz09
For access code of the links, check with TAs or the instructor
Logistics: Grading

Homeworks (40%)
• Exercises (Grade by completion)
• Assignments (Grade by content)

Project (25%)
• Theory or applications of convex optimization
• Survey of the state of the art approaches
• Outlines, references (W4)
• Report (6PM 3/18/2021, W11)

Exams (35%)
• Midterm, 2/16/2021, T (W7)
Logistics: Textbooks

Required text:
- Convex Optimization, Stephen Boyd and Lieven Vandenberghe, Cambridge, 2004
- Review appendix A in the first week

References
Classification: Brief history of convex optimization

Theory (convex analysis): 1900–1970

Algorithms
• 1947: simplex algorithm for linear programming (Dantzig)
• 1970s: ellipsoid method and other subgradient methods
• since 2000s: many methods for large-scale convex optimization

Applications
• before 1990: mostly in operations research, a few in engineering
• since 1990: many applications in engineering (control, signal processing, communications, circuit design, . . . )
• since 2000s: machine learning and statistics
## Classification

### Tradition

<table>
<thead>
<tr>
<th>Linear Programming</th>
<th>Nonlinear Programming</th>
<th>Discrete Integer Programming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplex</td>
<td>Lagrange multiplier</td>
<td>Trial and error</td>
</tr>
<tr>
<td>Primal/Dual</td>
<td>Gradient descent</td>
<td>Cutting plane</td>
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<tr>
<td>Interior point method</td>
<td>Newton’s iteration</td>
<td>Relaxation</td>
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### This class

<table>
<thead>
<tr>
<th>Convex Optimization</th>
<th>Nonconvex, Discrete Problems</th>
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</thead>
<tbody>
<tr>
<td>Primal/Dual, Lagrange multiplier</td>
<td>Local Optimal Solution Search, SA (Simulated Annealing), ILP (Integer Linear Programming), MLP (Mixed Integer Programming), SAT (Satisfiability), SMT (Satisfiability Modulo Theories), etc.</td>
</tr>
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Scope of Convex Optimization

For a convex problem, a local optimal solution is also a global optimum solution.
Scope

Problem Statement (Key word: **convexity**)
- Convex Sets (Ch2)
- Convex Functions (Ch3)
- Formulations (Ch4)

Tools (Key word: **mechanism**)
- Duality (Ch5)
- Optimal Conditions (Ch5)

Applications (Ch6,7,8) (Key words: complexity, optimality)

Coverage depends upon class schedule

Algorithms (Key words: **Taylor’s expansion**)
- Unconstrained (Ch9)
- Equality constraints (Ch10)
- Interior method (Ch11)
Scope

CSE203B Convex Optimization

- Optimization of convex function with constraints which form convex domains.

Background

- Linear algebra
- Polynomial and fractional expressions
- Log and exponential functions
- Optimality of continuously differentiable functions

Concepts and Techniques to Master in CSE203B

- Convexity
- Hyperplane
- Duality
- KKT optimality conditions