CSE203B Convex Optimization

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

• Staff
  – Instructor and TAs

• Logistics
  – Websites, Textbooks, References, Tasks and Grading Policy

• Scope
  – History and Category
  – Coverage
Staff

• Instructor
  – CK Cheng, ckcheng+203B@ucsd.edu

• TAs, Office hours: TBA (Piazza)
  – Chen, Danlu, email:dac013@ucsd.edu
  – Giri, Vijay, email:vgiri@ucsd.edu
  – Holtz, Chester, email:chholtz@ucsd.edu (Lead TA)
  – Magee, Lucas, email:lmagee@ucsd.edu
  – Singh, Abhishek, email:abs006@ucsd.edu
  – Song, Meng, email:mes050@ucsd.edu
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: Computer-Aided Design/Design Automation: VLSI Layout, Simulation, Brain Computer Interface (e.g. 3D chip layout technology optimization, graph visualization, quantum mechanic simulation, mouth intake sensing)
• Email: ckcheng+203B@ucsd.edu, Office: Room CSE2130
• Office hour will be posted on Piazza
• Websites
  – http://cseweb.ucsd.edu/~kuan
  – http://cseweb.ucsd.edu/classes/wi23/cse203B-a
Logistics: Class Schedule and Links

Class Lectures: 12:30-1:50 PM TTH, SOLIS 107
Discussion Sessions: 4:00-4:50 PM F, WLH 2001

Class Links

• Class website: Slides and announcements
  http://cseweb.ucsd.edu/classes/wi23/cse203B-a
• Canvas: Roster
• Piazza: Q&A platform
• Gradescope: Submissions of HWs, Exams, Projects
• UCSD Podcast: Video records of lectures and discussion sessions

For access of the links, check with Lead TA: Chester Holtz, chholtz@ucsd.edu
Logistics: Textbooks

Required textbook: (reading and part of HW assignment)

• Convex Optimization, Stephen Boyd and Lieven Vandenberghe, Cambridge, 2004 Review appendix A in the first week

References


• CMU Convex Optimization by R. Tibshirani, http://www.stat.cmu.edu/~ryantibs/convexopt/

• EE364a: Convex Optimization, http://stanford.edu/class/ee364a/

• https://cseweb.ucsd.edu/~kuan/ (CSE203B notes in previous quarters)
Logistics: Tasks

Homeworks
• Discussion is permitted (only for this class)
• Write the solution by oneself

Project
• A team of 4 or less members but no more than 4
• Teamwork is encouraged because of the scope and timeframe of the project
• Use piazza to search for team members

Exams
• Open book and internet search is allowed but no help from anyone else
Logistics: Grading

Homeworks (50%)
- Exercises from textbook (Grade by completion)
- Assignments (Grade by content)

Project (25%)
- Theory or applications of convex optimization
- Survey of the state of the art approaches
- Outlines and references (Due 2/1/2023, W4)
- Report (Due 230PM Tuesday 3/21/2023, W11)

Exams (25%)
- Take-home exam 48 hours
- Midterm, 2/26-27/2023, (W7-8)
Logistics: Grading/Expectation

- Level 1: Definitions and proofs (slides, taking notes in classes)
- Level 2: Examples and applications (hws)
- Level 3: New formulations and usage (exam, project)
- Level 4: Open problems (project, exam)
Scope of Convex Optimization

For a convex problem, a local optimal solution is also a global optimum solution.
Scope: 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
• 2000+: many methods for large-scale convex optimization

Applications
• before 1990: mostly in operations research, a few in engineering
• 1990+: many applications in engineering (control, signal processing, communications, circuit design, . . . )
• 2000+: machine learning and statistics
# Scope: Optimization 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>
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<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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</tbody>
</table>

## This class

<table>
<thead>
<tr>
<th>Convex Optimization</th>
<th>Nonconvex, Discrete Problems</th>
</tr>
</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>
<tr>
<td>Gradient descent</td>
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<td>Interior point method</td>
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Scope: Coverage

1. Problem Statement (Key word: convexity)
   • Convex Sets (Ch2)
   • Convex Functions (Ch3)
   • Formulations (Ch4)

2. Tools (Key word: transform mechanism)
   • Duality (Ch5)
   • Optimal Conditions (Ch5)

3. Applications (Ch6, 7, 8) (Key words: complexity, optimality)
   Coverage depends upon class schedule

4. Algorithms (Key words: Taylor’s expansion)
   • Unconstrained (Ch9)
   • Equality constraints (Ch10)
   • Interior method (Ch11)
CSE203B Convex Optimization

• Optimization of a 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