CSE203B Convex Optimization

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Dept. of Computer Science and Engineering

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Outlines

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Staff

- Instructor
  - CK Cheng, ckcheng+203B@ucsd.edu
- TAs, Office hours: TBA (Piazza)
  - Holtz, Chester, chholtz@ucsd.edu,
  - Liu, Isabella, lal005@ucsd.edu
  - Nagola, Ethan, enagola@ucsd.edu
  - Paksoy, Oguz, opaksoy@ucsd.edu
  - Ravindrakumar, Vaishakh, varavind@ucsd.edu
  - Song, Meng, 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. 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 the course website
- Websites
  – http://cseweb.ucsd.edu/~kuan
  – http://cseweb.ucsd.edu/classes/wi22/cse203B-a

Logistics: Class Schedule and Links

Class Lectures: 12:30-1:50 PM TTH, Centr 101

Discussion Sessions: 9:00-9:50 PM F Centr 101

Class website: Slides and announcements

http://cseweb.ucsd.edu/classes/wi22/cse203B-a

Piazza: Q&A platform
http://piazza.com/eng.ucsd/winter2022/cse203bwinter2022, or https://piazza.com/class/kx85xrdgigl5m5.

Gradescope: Submissions of HWs, Exams, Projects

UCSD Podcast: Records of lectures and discussion sessions

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

Logistics: Grading

Homeworks (50%)

- 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 and references (Due 1/28/2022, W4)
- Report (Due 2:30PM Tuesday 3/15/2022, W11)

Exams (25%)

- Take-home exam 48 hours
- Midterm, 2/20-21/2022, (W7-8)

Logistics: Grading/Expectation

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 in need of team members

Exams

- Open book and internet search is allowed but no help from anyone else

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 (project, exam)
- Level 4: Open problems (exam)

Logistics: Textbooks

Required textbook:

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

References

- Numerical Recipes: The Art of Scientific Computing, Third Edition, W.H. Press, S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery, Cambridge University Press, 2007.
- Matrix Computations, 4th Edition, G.H. Golub and C.F. Van Loan, Johns Hopkins, 2013.
- CMU Convex Optimization by R. Tibshirani, http://www.stat.cmu.edu/~ryantibs/convexopt/
- EE364a: Convex Optimization, http://stanford.edu/class/ee364a/

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
- 1980s & 90s: polynomial-time interior-point methods for convex optimization (Karmarkar 1984, Nesterov & Nemirovski 1994)
- 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

Optimization Classification

Tradition

Linear Programming	Nonlinear Programming	Discrete Integer Programming
Simplex	Lagrange multiplier	Trial and error
Primal/Dual	Gradient descent	Cutting plane
Interior point method	Newton's iteration	Relaxation

This class

Convex Optimization	Nonconvex, Discrete Problems
Primal/Dual, Lagrange multiplier	Local Optimal Solution Search, SA (Simulated Annealing), ILP (Integer Linear Programming), MLP (Mixed Integer Programming), SAT (Satisfiability), SMT (Satisfiability Modulo Theories), etc.
Gradient descent	
Newton's iteration	
Interior point method	

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: **transform 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 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