Convex Optimization II

EE 25088

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Department of Electrical Engineering

Sharif University of Technology

1400-2

COURSE INFORMATION

- Graduate course in optimization theory and its application
  - Combinatorial, convex, and non-convex optimization and their applications
- Instructor: **Hamed Shah-Mansouri**
  - Email: hamedsh@sharif.edu
  - Office: EE Building, Room 714
  - Office hours: Tuesdays 11:00 - 12:00 am (or by appointment)
- Lectures:
  - Time: Sundays and Tuesdays, 12:00 - 13:20 p.m.
  - Location: `https://vc.sharif.edu/ch/hamedsh`
- TA Sessions:
  - Time: Wednesday, 10:30 - 11:50 a.m.
  - Location: `https://vc.sharif.edu/ch/hamedsh-ta`
- Course website:
  - Sharif CourseWare

Course Information

- Pre-requisites (Informal)
  - Willing to learn, Comfortable with math
  - Already passed undergraduate Engineering Math and Probability and Statistics courses

- Grading

Course work	Approx (out of 21)
Problem sets*	2
Mid-term exam†	5
Project	4+1
Final exam	9

*Problem sets

- Try to work out the problems on your own but feel free to talk to other students.
- If you register this course for audit, you need to submit all problem sets.

†Midterm exam: Thursday, 22 Ordibehesht at 09:00 am.

Course Overview

Lecture 0: Motivation and Introduction

- Mathematical optimization
- Course goal
- Why to take this course?

Lectures 1–3: Combinatorial Optimization

- Linear programming and its applications (Multi-commodity flow problem)
- Mixed integer programming
- Approximation algorithms (LP relaxation, rounding methods)
- Set cover and Knapsack problem analysis

Course Overview

Lectures 4-8: Convex analysis and optimization

- Convex set and convex functions
- Convex optimization
- Lagrange dual problem, KKT optimality conditions
- Gradient and subgradient methods to solve convex optimization problems

Lectures 9–10: Decomposition methods and distributed optimization

- Dual decomposition
- Primal decomposition
- Indirect decomposition
- Hierarchical decomposition
- Applications and use cases

COURSE OVERVIEW

Lectures 11-13: Optimization in communication networks
Motivation: Apply what we have learned to communication network protocols

- Transmission Control Protocol (TCP)- Optimization-based congestion control
- Fairness in Resource Allocation Problems
- Generalized Network Utility Maximization

Lectures 14–16: Stochastic and robust optimization
Motivation: Providing online control strategies for time varying systems with general classes of penalties, rewards, and utility functions

- Optimization under uncertainty
- Risk averse optimization
- Optimization of infinite horizon time
- Lyapunov optimization
- Applications and use cases (Newsvendor problem, stock market analysis, stochastic networks, stable scheduling)

Course Overview

Lectures 17–19: Non-convex problems

- Regularization and Convexification
- Convex-Cardinality Problems
- Sequential convex programming
- Applications and use cases (learning, data fitting)

Lecture 20: Bandit Convex Optimization

- Applications in machine learning

Lecture 21: Large-scale optimization
Motivation: Dealing with large-scale optimization problems

- Alternating direction method of multipliers (ADMM)

Week 15: Project presentations

TEXT BOOKS

There is **no** required textbook for this course.

Useful Materials:

- Lecture notes and assigned papers
- S. Boyd and L. Vandenberghe, Convex Optimization, Cambridge University Press, 2004. (Free)
- V. Vazirani, Approximation Algorithms, Springer-Verlag, 2001.
- D.P. Bertsekas and J.N. Tsitsiklis, Parallel and Distributed Computation, Athena Scientific, 1997. (Free)
- M.J. Neely, Stochastic Network Optimization with Application to Communication and Queueing Systems, Morgan & Claypool, 2010. (Free)
- A. Shapiro and A. Philpott, "A Tutorial on Stochastic Programming"

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