ELEC5470/IEDA6100A - Convex Optimization
Fall 2020-21, HKUST

Basic Information

Instructor: Prof. Daniel P. Palomar (https://www.danielppalomar.com)
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Lecture Time: Mon 18:00 – 20:50
Lecture Venue: Online via Zoom (and Rm2405)

Description

In the last three decades, a number of fundamental and practical results have been obtained in the area of convex optimization theory. It is a well-developed area, both in the theoretical and practical aspects, and the engineering community has greatly benefited from these recent advances by finding key applications.

This graduate course introduces convex optimization theory and illustrates its use with many applications where convex and nonconvex formulations arise. The emphasis will be on i) the art of unveiling the hidden convexity of problems by appropriate manipulations, ii) a proper characterization of the solution either analytically or algorithmically, and iii) multiple practical ways to approach nonconvex problems.

The course follows a case-study approach by considering recent successful applications of convex optimization published within the last decade in top scientific journals in the areas of signal processing, finance, machine learning, and big data. Problems covered include portfolio optimization in financial markets, filter design, beamforming design in wireless communications, classification in machine learning, circuit design, robust designs under uncertainty, sparse optimization, low-rank optimization, graph learning from data, discrete maximum likelihood decoding, network optimization, distributed algorithms, Internet protocol design, etc.

Textbooks

- S. Boyd and L. Vandenberghe. *Convex Optimization*. Cambridge University Press, 2004. [https://web.stanford.edu/~boyd/cvxbook/]
- Daniel P. Palomar and Yonina C. Eldar, *Convex Optimization in Signal Processing and Communications*, Cambridge University Press, 2009.

Prerequisites:

Students are expected to have a solid background in linear algebra. They are also expected to have research experience in their particular area and be capable of reading and dissecting scientific papers.

Grading:

Homework:	25% (auditors too)
Midterm:	15% (auditors too)
Class participation:	10% (Zoom video on)
Final Project:	50% (homeworks and midterm are required to be passed)

Course Schedule

Date	Week	Lec	Topic
7-Sep	1	1	Introduction
		2	Theory: Convex sets and convex functions
14-Sep	2	3	Theory: Convex problems and taxonomy (LP, QP, SOCP, SDP, GP)
		4	Application: Filter design
21-Sep	3	5	Theory: Algorithms primer (Newton, IPM, BCD)
		6	Application: Disciplined convex programming - CVX
28-Sep	4	7	Theory: Lagrange duality and KKT conditions
		8	Application: Waterfilling solutions
5-Oct	5	9	Application: Markowitz portfolio optimization
		10	Theory&Application: Geometric programming (GP)
12-Oct	6	11	Theory&Application: MM and SCA based algorithms
		12	Application: Risk parity portfolio in finance
19-Oct	7	13	Application: Sparsity via l_1-norm minimization
		14	Application: Sparse index tracking in finance
2-Nov	8		- Midterm -
9-Nov	9	15	Application: Classification and SVM in machine learning
		16	Application: Low-rank optimization problems (Netflix, video security)
16-Nov	10	17	Application: Robust optimization with applications
		18	Application: Graph learning from data
23-Nov	11	19	Application: ML decoding via SDP relaxation
		20	Application: Rank-constrained SDP and multiuser downlink beamforming
30-Nov	12	21	Theory: Primal/dual decomposition techniques
		22	Application: The Internet as a convex optimization problem

	extra	Application: Norm minimiz. with applications to image processing
		Application: blind separation via convex optimization in image proc.
		Application: MIMO transceivers based on Majorization Theory
		Theory: numerical algorithms – cutting plane and ellipsoid methods
		Application: segmentation and Multiview Reconstruction in Image Processing
		Application: multiuser MIMO transceiver design
		Application: dual decomposition for sum-power sum-capacity of MIMO MAC (IWFA)
		Application: primal decomposition for multicarrier MIMO transceiver design
		Theory: the S-procedure for robust design
		Theory: minimax problems
		Theory: nonconvex optimization and complexity (NP-ities)
		Theory: Variational Inequality Theory
		Application: Cognitive Radio Systems via Variational Inequality