ELEC5470 - Convex Optimization
Fall 2017-18, HKUST

Basic Information

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ELEC5470 – Convex Optimization [3-0-0:3]
Website: http://www.danielppalomar.com/elec5470---convex-optimization.html
Lecture Time: Mon 18:00 - 20:50
Lecture Venue: LSK1009 (Lee Shau Kee Business Building)

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 applications.

This graduate course introduces the basic theory and illustrates its use with many recent applications in signal processing, communication systems, machine learning, networking, robust design, image processing, financial engineering, etc. The emphasis will be on i) the art of unveiling the hidden convexity of problems by appropriate manipulations, and ii) a proper characterization of the solution either analytically or algorithmically. The course follows a case-study approach by considering recent successful applications of convex optimization published within the last decade in top scientific journals.

Problems will be covered in areas of signal processing such as filter/beamforming design, circuit design, robust designs under uncertainty, sparsity optimization, low-rank optimization, image processing, classification methods, portfolio optimization in financial systems, discrete maximum likelihood decoding, transceiver design for MIMO channels, cognitive radio systems, network optimization, distributed algorithms, wireless network power control, Internet protocol design, etc.

Textbooks

- S. Boyd and L. Vandenberghe, *Convex Optimization*, Cambridge University Press, 2004. [http://www.stanford.edu/~boyd/cvxbook/]
- Daniel P. Palomar and Yonina C. Eldar, *Convex Optimization in Signal Processing and Communications*, Cambridge University Press, 2009.
- D. P. Bertsekas, *Nonlinear Programming*, Athena Scientific, Belmont, Massachusetts, 2nd Ed., 1999.

Prerequisite:

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

Grading:

Homework: 10%
Quizzes: 10% (auditors too)
Midterm: 20% (auditors too)
Final Project: 60% (homeworks and midterm are required to be passed)

Course Schedule

Date	Lec	Topic	HM out	HM in
4-Sep	1	Introduction		
	2	Theory: convex sets and convex functions		
11-Sep	3	Theory: convex problems and classes of convex problems (LP, QP, SOCP, SDP, GP)		
	4	Application: norm minimiz. with applications to image processing	HM1	
18-Sep	5	Application: filter design		HM1
	6	Theory: disciplined convex programming - cvx	HM2	
25-Sep	7	Theory: Lagrange duality and KKT conditions		HM2
	8	Application: waterfilling solutions	HM3	
9-Oct	9	Theory: numerical algorithms – interior point method		HM3
	10	Application: worst-case robust beamforming	HM4	
16-Oct	11	Theory: MM-based algorithms		HM4
	12	Theory&Application: Geometric Programming (GP)	HM5	
23-Oct	13	Application: l_1-norm minimization for convex-cardinality problems		HM5
	14	Application: Sparse Index Tracking in Finance		
30-Oct		Midterm		
6-Nov	15	Application: classification and SVM in machine learning		
	16	Application: ML decoding via SDP relaxation		
13-Nov	17	Application: rank-constrained SDP and multiuser downlink beamforming		
	18	Application: portfolio optimization in financial engineering		
20-Nov	19	Application: low-rank optimization problems (Netflix, video security)		
	20	Application: blind separation via convex optimization in image proc.		
22/23-Nov	21	Theory: primal/dual decompositions techniques		
	22	Application: alternative decompositions for NUM in wired and wireless networks		
27-Nov	23	Application: the Internet as a convex optimization problem		
	24	Summary		

	extra	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