11110COM 524500 Convex Optimization for Communications and Signal Processing

(通訊及信號處理之凸優化方法) **(Fall Semester 2022)**

Lecture hours: **M3,M4 (Delta 212), R3,R4 (Delta 208)**

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Office hours: 13:30 pm-15:30 pm (Tuesday & Wednesday)

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Convex Optimization *has been recognized as a powerful tool for solving many science and engineering problems. Over the last two decades, convex optimization has been successfully and extensively applied to various problems in communications and signal processing such as (a) multiple-input multiple-output (MIMO) wireless communications and networking for 5G-beyong and 6G, (b) blind source separation (BSS) for biomedical and hyperspectral image analysis, and (c) machine learning (ML). In particular, many ML methods (e.g., Lasso, and Support Vector Machines) are based on the identification of some parameters by minimizing an objective function, defined by the sum of a loss function and some regularization terms (e.g., linear regression, and L1-norm regularization). The resulting optimization problem can be optimally solved through reformulation into a convex problem in many instances, thus* ***naturally forming a strong link and mutual need between ML and convex optimization in real-world applications.*** *This course is to introduce convex optimization concepts and methods, available software and their applications.* **Youtube:** https://www.youtube.com/watch?v=1isVbbMsGs4

Background: Calculus and linear algebra are prerequisites, while matrix analysis is desirable.

Course Outline:

1. Background materials in linear algebra and matrix analysis
2. Convex sets
3. Convex functions
4. Convex optimization problems
5. Duality
6. Interior-point methods
7. Applications to communications/signal processing and other engineering problems

Textbook:

Chong-Yung Chi, Wei-Chiang Li, and Chia-Hsiang Lin, Convex Optimization for Signal Processing and Communications: From Fundamentals to Applications, CRC Press, Boca Raton, FL, 2017 (432 pages).

http://st-ebook.com.tw/bookcomment-2.aspx?BOKNO=TKCP00033 (科大文化圖書公司)

The material of the textbook systematically introduces how to efficiently and effectively solve an ***optimization problem****, from the fundamental theory, problem definition, reformulation into a convex problem, analysis, algorithm implementation, to cutting edge researches (like an exploration journey rather than pure mathematics) in signal processing and communications. It has been used for my 2-week (32 lecture hours) or 3-week (48 lecture hours) invited short course entitled "****Convex Optimization for Signal Processing and Communications****" at many top ranked universities in Mainland China over the last decade, including* ***Shandong University****, Jinan (January 2010, November 2017),* ***Tsinghua University****, Beijing (August 2010 and August 2012),* ***Tianjin University****, Tianjin (August 2011),*

***Beijing Jiaotong University (BJTU)**, Beijing (July 2013, July 2015 and August 2017), **University of Electronic Science and Technology of China,** Chengdu (November 2013, September 2014 and September 2015), **Xiamen University**, Xiamen (December 2013), **Sun-Yet-Sen University (SYSU),** Guangzhou (August 2015), and **Beijing University of Posts and Telecommunications**, Beijing (July 2016, July 2017, July 2018, July 2019), **Shandong Normal University**, Jinan (Aug. 2018), and **Xidian University** (Aug. 2019).*

References:

Boyd and Vandenberghe, *Convex Optimization*, Cambridge University Press, Cambridge, 2004. E-book can be downloaded from: http://www.stanford.edu/~boyd/cvxbook/
Giuseppe Calafiore and Laurent El Ghaoui, *Optimization Models*, University Press, Cambridge, 2014.
R. Fletcher, *Practical Methods of Optimization*, John Wiley and Sons, 1988.
D. P. Bertsekas, *Convex Analysis and Optimization*, Athena Scientific, 2003.
D. P. Bertsekas, *Convex Optimization Theory*, Athena Scientific, 2009.
Daniel P. and Yonina C. Eldar (Editors), *Convex Optimization in Signal Processing and Communications*, Cambridge University Press, Cambridge, 2010.

Grading:

Homework: 25%
Final Exam: 50%
Term Project: 25%
Teaching assistant: **Michelle Lin (林孟萱)**, e-mail: michelle889886@gmail.com, Tel: X34033,
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Teaching assistant: **Chien-Wei Huang (黃健瑋)**, e-mail: s110064501@gmail.com, Tel: X34033,
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Remarks:

1. This course will be taught ***in English if there are international students.***
2. Homework assignments (pdf files) must be submitted on the required date. Late submission is not acceptable; plagiarism will get serious penalty.
3. No make-up for any examination under any circumstances.
4. *Nonlinear adjustment* will be made for the final term grade as needed.

Digital Platforms:

1. Skype Group on-line teaching: https://join.skype.com/vmxf4x54kWfO ***depending on COVID-19.***
2. Course website: https://www.ee.nthu.edu.tw/cychi/teaching/cvx_comm.php
3. Information (e.g., Homework, Examination, Term Projects) will be announced on NTHU EEclass website: https://eeclass.nthu.edu.tw/