GRADUATE SUMMER SCHOOL ON OPTIMIZATION:

OPTIMIZATION IN DATA SCIENCE AND MACHINE LEARNING

About the Speaker:

Yinyu Ye is currently the K.T. Li Professor of Engineering at Department of Management Science and Engineering and Institute of Computational and Mathematical Engineering, Stanford University. He received the B.S. degree in System Engineering from the Huazhong University of Science and Technology, China, and the M.S. and Ph.D. degrees in Engineering-Economic Systems and Operations Research from Stanford University. His current research interests include Continuous and Discrete Optimization, Data Science and Application, Algorithm Design and Analysis, Computational Game/Market Equilibrium, Metric Distance Geometry, Dynamic Resource Allocation, and Stochastic and Robust Decision Making, etc. He is an INFORMS (The Institute for Operations Research and The Management Science) Fellow since 2012, and has received several academic awards including: the inaugural 2006 Farkas Prize on Optimization, the 2009 IBM Faculty Award, the 2009 John von Neumann Theory Prize for fundamental sustained contributions to theory in Operations Research and the Management Sciences, the inaugural 2012 ISMP Tseng Lectureship Prize for outstanding contribution to continuous optimization (every three years), the winner of the 2014 SIAM Optimization Prize awarded (every three years), the 2015 SPS Signal Processing Magazine Best Paper Award, etc.. He has supervised numerous doctoral students at Stanford who received various prizes such as INFORMS Nicholson Prize, Student Paper Competition, the INFORMS Computing Society Prize, the INFORMS Optimization Prize for Young Researchers. According to Google Scholar, his publications have been cited 49000 times.

Course Information:

The course emphasizes high level pictures of (convex or nonconvex) Optimization/game, including classical duality and fix-point theories, KKT conditions, efficient algorithms and recent progresses in Linear and Nonlinear Optimization/Game---one of the central mathematical decision models in **Data Science, Machine/Reinforcement Learning, Business Analytics, and Operations Management**.

The field of optimization is concerned with the study of maximization and minimization of mathematical functions. Very often the arguments of (i.e., variables in) these functions are subject to side conditions or constraints. By virtue of its great utility in such diverse areas as applied science, engineering, economics, finance, medicine, data analysis, machine learning and statistics, optimization holds an important place in both the practical world and the scientific world. Indeed, as far back as the Eighteenth Century, the famous Swiss mathematician and physicist Leonhard Euler (1707-1783) proclaimed that *... nothing at all takes place in the Universe in which some rule of maximum or minimum does not appear.* The subject is so pervasive that we even find some optimization terms in our everyday language.

Optimization often goes by the name *Mathematical Programming* (MP). The latter name tends to be used in conjunction with finite-dimensional optimization problems, which in fact are what we shall be studying here. The word "Programming" should not be confused with computer programming which in fact it antedates. As originally used, the term refers to the timing and magnitude of actions to be carried out so as to achieve a goal in the best possible way.

Topics which you would learn in this course include:

Decision Models/Applications - Online Pricing and Resource Allocation, Markov Decision Process and Reinforcement Learning, Data Classification via Wasserstein Barycenter, Sensor-Network Localization, Neural-Learning Verification, Distributionally Robust Decision-making and Learning, Economic/Game Equilibrium, Financial Techniques and Risk Management, Sparse and Low Rank Regression, Conic Linear Optimization, etc.

Theories - Alternative-Theorems, Optimality Conditions, Conic and Lagrangian Duality, Complexity Analyses;

Algorithms/Methods - Steepest Descent, Multiplicative-Descent, Accelerated Descent, Block-Coordinate Descent, Stochastic Gradient Descent, Newton Descent, Dimension-Reduced Newton, Path-Following Methods, Descent-First and Feasible-Second, Interior-Point Methods, Lagrangian Relaxations, ADMM methods, Optimization with random samplings and column generation, and other fast/heuristic Algorithms for NONCONVEX optimization with certain provable guarantee.

Reading Materials:

David Luenberger and Yinyu Ye, *Linear and Nonlinear Programming, 5th Edition*.

Assignments:

5 self-grading assignments.

1 self-grading take-home midterm exam.

1 team (up to 4 people) project on one of suggested computational projects. Project reports would be presented in the last day of the class.

Pre-requisites:

Open to all level of students, who in this course will be expected to possess a firm background in the following mathematical subjects: multivariate differential calculus; fundamental concepts of analysis; linear algebra and matrix theory. Familiarity with computers and computer programming are also be useful, since various algorithm implementation projects can be substituted for the final exam. Above all, it is essential to have a tolerance for mathematical discourse plus an ability to follow - and devise one's own - mathematical proofs.

Schedule:

Day	Date	Time	Venue
Wednesday	15 June 2022	10am – 12 noon	BIZ1 3-7 Seminar Room
Friday	17 June 2022		
Wednesday	22 June 2022		
Friday	24 June 2022		
Wednesday	29 June 2022		
Friday	1 July 2022		
Wednesday	6 July 2022		
Friday	8 July 2022		
Wednesday	13 July 2022		
Friday	15 July 2022		
Wednesday	20 July 2022		I4-01-03 Seminar Room
Friday	22 July 2022		
Wednesday	27 July 2022		
Friday	29 July 2022		
Wednesday	3 August 2022		
Friday	5 August 2022*		

**Note: For the last session on 5 August 2022, the project presentations will take place from 12pm – 2pm.*