IE 510 – Applied Nonlinear Programming
Spring 2018

Tu & Th: 2:00pm – 3:20PM, Engineering Hall 410C1

Last revised: 01/15/2018

Course info

Instructor: Ruoyu Sun, assistant professor, ISE and CSL

Email: ruoyus@illinois.edu

Office location: Transportation Bldg 209D

Instructor Office Hour: Tuesday, 3:30-4:30pm or by appointment via email

TA Office Hour: Thursday, 12:30-1:30pm, 14 Transportation Bldg(basement)

Course time/location: Tu & Th: 2:00pm – 3:20PM, Enigneering Hall 410C1

TA: Lei Fan leifan2@illinois.edu

Course Description

Nonlinear programming is about optimizing not-necessarily-linear functions possibly subject to constraints. It finds applicability in a variety of fields ranging from machine learning, statistics, economics, finance, to various engineering disciplines. In this course, we will study the basic theory of nonlinear optimization and many different methods in nonlinear optimization with application examples from data analytics and machine learning. The course focus on the fundamental subjects in nonlinear optimization, as a complementary to IE 411 (Optimization of Large Systems), IE 511 (Integer Programming), and IE 521 (Convex Optimization).

Besides students within IE, this course would be of interest to students from math, ECE, economics, computer science, and most engineering disciplines. No prior background in optimization will be required. However, please note that this will be a mathematically sophisticated class that will require you to be comfortable with writing rigorous proofs.

Prerequisites

Basic knowledge of linear algebra and calculus is necessary. Some knowledge of numerical linear algebra, probability and complexity theory will be helpful.

Material

Textbook: Dimitri Bertsekas, "Nonlinear Programming".

Other references:

- Luenberger and Ye. Linear and nonlinear programming. Edition 4.
- Nesterov. Introductory Lectures on Convex Optimization: A Basic Course. Kluwer-Academic. 2003

- S. Sra, N. Sebastian, and S. Wright. Optimization for machine learning. Mit Press, 2012.
- S. Bubeck "Convex optimization: Algorithms and complexity." Foundations and Trends® in Machine Learning 8.3-4 (2015): 231-357.
- Bottou, Léon, Frank E. Curtis, and Jorge Nocedal. "Optimization methods for large-scale machine learning." arXiv preprint arXiv:1606.04838 (2016).

Grading policy

- Numerical grade = homework (35%) + 1 in-class exam (30%) + class project (30%) + attendance (5%).
- Submitting homework electronically in pdf format is encouraged
- Late homework and exam will not be accepted or graded, unless pre-approved by the instructor
- Makeup exam: If you need to reschedule an exam, you must request a makeup exam and submit evidence of necessity at least 24 hours in advance
- Bonus points: you will earn bonus points if you solve bonus problems in the homework/exam
- There is zero tolerance on academic misconduct. Individuals suspected of committing academic dishonesty will be directed to the Dean of Students Office as per University policy. **Penalty for academic misconduct** (up to 100%).
- Project (30%): Apply optimization methods to a practical problem in data analytics, machine learning or your own field, or explore a theoretical question. Write a report with 5-10 pages.

Course Contents

- Unconstrained optimization: optimality conditions, gradient methods, Newton's method
- Constrained optimization: necessary and sufficient conditions, conditional gradient method, gradient projection methods.
- Lagrangian Multiplier Theory: KKT conditions, Equality/Inequality Constrained Problems, linearly constrained problems, duality theory
- Penalty method, method of multipliers, barrier method, augmented Lagrangian method
- Advanced topics (as time permits): linear system of equations and conjugate gradient methods, proximal gradient method, ADMM (alternating direction method of multipliers), accelerated methods, neural networks, matrix/tensor decomposition

Collaboration Policy

- In-class and after-class discussions are strongly encouraged.
- One homework submission per person. Copying of others' homework is not allowed.
- No collaborations during the exams.