IE 510 – Applied Nonlinear Programming
Spring 2022
Tu & Th: 2:00pm – 3:20PM, TB112 & Zoom
Last revised: 01/12/2022

Course info
Instructor: Ruoyu Sun, assistant professor, ISE and CSL

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Office location: Transportation Bldg 209D

Instructor Office Hour: Wednesday, 8-9am or by appointment via email

TA: Kangcheng Lin, email: klin14@illinois.edu

TA Office Hour: TBD

Course time: Tu & Th: 2:00pm – 3:20PM.
Location: Zoom & TB112.
Phase 1: Online teaching, using media space to deliver course videos. (unknown length; likely to be at least a few weeks; check email for update)
Phase 2: In-person teaching.

Course website: https://wiki.illinois.edu/wiki/display/IE510SP22
Check course website for more details of the syllabus.

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:

- Nocedal and Wright, Numerical Optimization.
- 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.
- 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 (35%) + class project (30%)
- Submitting homework electronically to gradescope is required. The submitted homework should be in a single pdf file (except computer codes)
- You have 3 grace days for late homework submission
- 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 10-20 pages.

Course Contents

- Unconstrained optimization: optimality conditions, gradient methods, Newton's method, Heavy ball method, Nesterov's accelerated method, coordinate descent, SGD (Stochastic gradient methods), etc.
- Constrained optimization: optimization over convex sets, gradient projection methods, Equality/Inequality constrained problems, KKT conditions, duality theory
- Algorithms for constrained problems: (quadratic) penalty methods, method of multipliers (augmented Lagrangian method, ALM), dual ascent, ADMM
- Applications: logistic regression, SVM, matrix factorization, neural networks, LASSO

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.