SIE 645: Nonlinear Optimization

Fall 2022

Instructor: Dr. Erfan Yazdandoost Hamedani
Office: ENGR 321
Office Hours: Mon/Wed 2:00PM-03:00PM
Email: erfany@arizona.edu
Phone: 520-621-6548

Time and Location: Mon/Wed 4:30PM-05:45PM, In-Person, ENGR 301

Course Description: (3 units) This course is devoted to structure and properties of practical algorithms for unconstrained and constrained nonlinear optimization.

Prerequisites: SIE544–Linear Programming, or SIE 545–Fundamentals of Optimization, or equivalent. Knowledge of calculus, linear algebra, some mathematical analysis, and basic optimization models and methods.

Course Objective: In this course, students will develop the knowledge in the basic theory and algorithms for nonlinear optimization (unconstrained and constrained), including: understanding how algorithms work; choosing appropriate method to solve the problem in different situations; interpreting the performance of algorithms and analyzing the solutions for decision making.

Course Website: This class will use web-based D2L (Desire to Learn) as the only means of distributing class materials including homework assignments, lecture notes, supplemental readings, etc. Students must check the announcements in D2L at least once a week.

Books:

1. J. Nocedal and S.J. Wright, Numerical Optimization(2nd edition), Springer, 2006.
2. M.S. Bazaraa, H.D. Sherali, and C.M. Shetty, Nonlinear Programming: Theory and Algorithms, 3rd edition, Wiley & Sons Inc, New Jersey, 2006.
3. A. Beck, Introduction to nonlinear optimization: Theory, algorithms, and applications with MATLAB, Society for Industrial and Applied Mathematics, 2014.

Other References: S. Boyd and L. Vandenberghe, Convex Optimization, Cambridge University Press, 2004. Available online at: http://www.stanford.edu/ boyd/cvxbook

Course Outline: (Tentative)

1. Introduction
    - Optimization basics
    - Convex set and function
2. Unconstrained nonlinear optimization
    - Optimality conditions
    - Overview of algorithms
    - Smooth optimization
        - Gradient methods
        - Line search methods
        - Newton's method
        - Quasi-Newton methods
        - Trust-region
        - Conjugate gradient
    - Nonsmooth optimization
        - Subgradient method
        - Proximal gradient method
3. Constrained nonlinear optimization
    - Theory of constrained optimization
    - Quadratic programming
    - Penalty methods
    - Augmented Lagrangian methods
    - Primal-dual first-order methods (saddle point)
    - Sequential quadratic programming methods
    - Interior-point methods
    - Bilevel optimization

Grading Scale and Policies:
The grade for this course will be determined as follow:

- Homework assignments: 10%×5–submit a PDF file on D2L.
- Project: 35% (Introduction 5% Methodology 10%, Numerical results 10%, References 5%)

  - Topics will be given to or decided for each student during the first or second month of the class.
  - Students should find at least five related papers for the literature review.
  - You are expected to use modeling techniques to formulate a complex problem from industrial engineering, management science, data analytics, transportation engineering, etc.; or make progress in some well-known nonlinear optimization problems; develop algorithms to solve the problem, and analyze the numerical results. Software, such as MATLAB or Python can be used for the numerical experiments.
  - Final report should be a PDF file in a Journal format (a Latex/Word template will be given).

- Project presentation: 15%. Last few lectures of the class will be assigned to students to present the results of their project in about 15$\sim$20 minutes.

Class Guidelines:
All students:

- Check D2L regularly.
- Turn-in assignments by due date/time.
- Treat instructors, speakers and peers with respect.
- Always behave in an ethical manner.
- All students are required to abide by the Student Code of Academic Integrity: Student Code of Academic Integrity.
- Threatening behavior by students is strictly prohibited. For detailed information see: Threatening behavior by students and disruptive behavior in an instructional setting.

Classroom attendance:

- If you feel sick, or may have been in contact with someone who is infectious, stay home. Except for seeking medical care, avoid contact with others and do not travel.
- Notify your instructors if you will be missing an in person or online course.
- Campus Health is testing for COVID-19. Please call (520) 621-9202 before you visit in person.
- Visit the UArizona COVID-19 page for regular updates.