STOR 614 – Linear Programming and Extensions

(Spring 2020)

Time and space

1:25PM - 2:40PM: Mondays - Wednesdays Room: Hanes 125

Staff

Instructor: Quoc Tran-Dinh (quoctd@email.unc.edu)

Office hours: Mondays and Wednesdays, 11:00 – 12:00pm (tentative).

Overview

STOR614 aims at providing basic theory and computational methods for linear programming (LP) and its extensions. First, we will discuss different aspects of LPs including preprocessing, geometry, duality theory, sensitivity analysis, and applications. Then, we will present some common solution methods such as simplex and interior-point methods. Extensions of LPs such as quadratic programming, second-order cone, and semidefinite programming are also planned to cover at an introductory level. Next, some selected topics in convex optimization will be studied such as optimality and KKT (Karush-Kuhn-Tucker) conditions, duality theory, and first-order methods. Finally, we will consider some representative applications of convex optimization such as LASSO, portfolio selection, robust linear programming, and support vector machine.

Prerequisites

This course requires basic knowledge from numerical linear algebra and multivariable calculus at least from the MATH547/MATH577 level or equivalence (e.g., STOR 415, or STOR 612). If student does not have such background, then I will highly recommend dropping the course.

Topics

1. Introduction: mathematical optimization
   - Mathematical optimization problems and terminologies
   - Examples of optimization problems
2. Linear programming
   - Standard and canonical forms
   - Preprocessing and post-processing
   - Representative applications
3. Geometric structures of linear programming
   - Convex sets, convex hulls, and convex combinations
   - Theory of polyhedral sets

- Basic solutions and optimal solutions

4. Simplex methods
   - Simplex method in matrix form
   - Simplex method with simplex tableaux
   - Two-phase simplex method
5. Duality in linear programming
   - Primal and dual forms
   - Duality theory: weak and strong duality, complementarity slackness
6. Sensitivity analysis for linear programming
   - Sensitivity analysis with data perturbation
   - Robustness counterparts (if time permits)
7. Convex quadratic programming
8. Second-order cone and semidefinite programming
9. Introduction to interior-point methods
   - Barrier and path-following methods
   - Primal-dual interior-point methods
10. Introduction to convex programming
    - Review on convex functions
    - Convex optimization problems
    - Representative examples
    - The gradient method and its variants
11. Introduction to constrained convex optimization (if time permits)
    - Problem formulation and examples
    - Dual problem and KKT condition
    - An overview on solution methods

While these topics are planned to cover in class, depending on the timeline of the course, some of them may be shortened or may be assigned as a reading topic to students.

Course material

A series of lecture notes is specially prepared for this course and will be available in Sakai. Students can buy some textbooks listed below, but they are not mandatorily required for this course. The lecture notes must internally be used in this course. Do not distribute the lecture notes in any form without a permission from the instructor.

For linear programming, the instructor will primarily use Bertsimas-Tsitsiklis's book below.

Here are some useful textbooks. Some of them will partly be used in this course:

1. D. Bertsimas and J. N. Tsitsiklis: Introduction to Linear Optimization. Athena, 1997.
2. R. Vanderbei: Linear programming: Foundations and extensions, 4th edition, 2014.
3. G. B. Dantzig: Linear programming and extensions. Princeton Press, 1963 (2 volumes).
4. A. Ben-Tal and A. Nemirovskii: Lectures on Modern convex optimization, SIAM, 2001.
5. M. C. Ferris, O. L. Mangasarian and S. J. Wright: Linear Programming with MATLAB. SIAM, 2008.
6. S. Boyd and L. Vandenberghe: Convex optimization, Cambridge Publisher, 2006. This book is free to download at: https://web.stanford.edu/~boyd/cvxbook/.
7. S. J. Wright: Primal Dual Interior-point methods, SIAM, 1997.
8. Y. Nesterov: Introductory lectures to convex optimization, Kluwer Academic Publisher, 2004.
9. J. Nocedal and S. J. Wright: Numerical Optimization. Springer, 2006.
10. A. Beck: Introduction to Nonlinear Optimization: Theory, Algorithms, and Applications with Matlab, SIAM, 2014.

Class attendance and course website

Students are expected to attend all classes. Students are responsible for assignments or policies that are announced in class or in material handed out in class, whether or not students are in class. Students are also responsible for any material distributed electronically by email or via the course webpage.

A course website is available at https://sakai.unc.edu/. Once student logs in with his/her ONYEN and password, go to the course site entitled STOR614.001.SP20. We will use it for making assignments, posting lecture notes and grades, and for other purposes.

Homework

Homework will be assigned in most weeks. It will be posted at the course site on the "Assignments" page. It will be due on dates stated in the assignment information posted in Sakai; it will be graded, and the grades returned to you, usually within one week.

Any homework not turned in at the regular class meeting must be deposited in the grader's mailbox at Hanes 310 before 5:00 P.M. on the due date. Do not deposit homework in the instructor's mailbox or the instructor's office. Unless specifically approved by the instructor, homework will not be accepted via email or other electronic forms. In general, late homework will receive no credit. Occasionally, reasonable exceptions may be made, with the instructor's specific approval in each case. Verbatim copying of homework is absolutely forbidden and constitutes a violation of the Honor Code.

To receive full credit on homework, students must:

- show all work neatly, write in blue or black pen or pencil, with student's name in blue or black ink on every page;
- clearly label each problem;
- staple the entire assignment together in the correct order.

Students who believe their grade on an assignment or examination is in error can request adjustment of the grade during a period of three weeks after the due date of the item in question. The three-week period may be shortened for the last one or two assignments of the semester. Any questions regarding homework grades should first be taken up with the grader; if these questions cannot be resolved with the grader, then feel free to discuss them with the instructor.

Exams

There will be one in-class examination (75 minutes), scheduled on Wednesday 26, February 2020, and one final examination (three hours) at 12:00 P.M. on Thursday, April 30, 2020. Any questions regarding exam grades should be taken up with the instructor. There is no make-up exam for the midterm one. If student has an official reason such as sickness, please contact the instructor to discuss possible solutions. This arrangement should be done as early as possible before the exam if student already has a plan, or after the exam, otherwise.

Course grade

A student's course grade will be based on the final course average, in computing which the graded work will be weighted as follows: regular homework assignments: 25%; in-class examination: 25%; final exam: 50%. No homework assignment is dropped.

All questions about course registration and waitlists should be directed to Ms. Christine Keat (mailto: crikeat@email.unc.edu, Hanes 321, 919-962-2307).

Each student is responsible for verifying his or her recorded scores (homework & in-class exams) during the semester. The Honor Code will be observed at all times in this course. The terms of the Honor Code are set out at http://instrument.unc.edu.

Surveys

The instructor may launch one or two surveys to get students' feedback. These surveys are completely anonymous. Students can write their comments and suggestions to help the instructor improving his teaching progress and the quality of the course.