Instructor: Prof. Yiling Chen (yiling@seas.harvard.edu, Office SEC 5.306)

Teaching Fellow: Tao Lin (tlin@g.harvard.edu)

Please send all course related emails to am122@g.harvard.edu . Emails sent to this address will reach both Yiling and Tao and will be responded more promptly.

Meeting time: Tuesdays and Thursdays 9:45 am - 11 am ET

Location: SEC 1.414. (Please note the location change.)

Office Hours:

- Yiling: 10 am - 11:30 am on Wednesday, in MD (Maxwell Dworkin) 151 (or over Zoom when necessary) and by appointment.
- Tao: contact me if you want a different time or format.
  - 11:30 - 12:30 on Thursday, in SEC 5.401.
  - 15:00 - 16:00 on Friday, over Zoom.

Overview

Many problems that arise in applications, including machine learning, statistics, finance, and engineering, can be formulated as a constrained optimization problem. We cannot generically solve every optimization problem efficiently. Fortunately, many problems of interest share some special properties, an important one being convexity, which permits efficient solution techniques.

This course focuses on recognizing, formulating, and solving convex optimization problems that arise in applications. We will introduce basic convex analysis (e.g. convex sets, convex functions, and optimization problems), discuss convex optimization theory (e.g. optimality conditions and duality theory), introduce tools and methods for solving convex optimization problems, and touch on some advanced topics. We will explore all these in the context of applications, particularly drawn from machine learning, statistics, and finance. The objective is to give students the theoretical training to recognize and formulate convex optimization problems and provide students with the tools and methods to solve the problems in their own applications of interest.

Please check out the Schedule page for a tentative week-by-week schedule.

Prerequisites

Linear algebra (as taught by, e.g., AM 21b or Math 21b/22a/25a/55a), linear programming (as taught by, e.g. AM 121), and some basic understanding of probabilities. Unofficially, a strong desire to learn, some mathematical maturity, and comfort with computational tools will help.

Textbook

We will use the wonderful book, Convex Optimization by Boyd and Vandenberghe, for a lot of topics covered in class. The PDF of the book is available online for free (http://www.stanford.edu/~boyd/cvxbook/). However, it's worth owning a hard copy of the book.

Format of the course

The course is designed to have a mixture of pre-class readings, lectures, and in-class activities.

Pre-class readings:

Many class meetings are preceded by a reading assignment with simple comprehension questions. These are due by the beginning of class. It is very important to keep on top of the reading, and familiarity with the reading will be assumed during the lecture. We do not expect you to fully understand everything before coming to class, but the goal is to prepare for class, familiarize yourself with new terminology and definitions, and be ready to ask about things that you find especially confusing. It is also important to attend class.

In-class activities:

The course has in-class small group activities for many of the meetings. These activities are intended to help you learn the materials more thoroughly. Active participation is crucial for your success in this course.

Software

We'll use CVXPY as the modeling language for convex optimization problems. CVXPY is an open-source Python-embedded modeling language. It allows fast prototyping.

We do not assume prior mastery of Python or CVXPY, but expect that you'll be willing to pick up the necessary knowledge for using the tools. Feel free to reach out to the TF if you encounter any difficulty with programming.

Support Resources

Online Q+A. We will be using an online Q&A platform. If your question would reveal confidential information or give away answers to homework questions, please make your post anonymous. We also encourage you to answer each other's questions. All announcements will be made on the platform.

Office hours. Please make use of staff office hours! You are welcome to come with specific questions about the material or just chat about things you find interesting.

Learning outcomes

After completing the course, we expect that you will

- Be able to translate a qualitative optimization idea or question into a mathematical formulation.
- Be able to recognize whether a mathematical optimization model is or can be translated into a convex model
- Become familiar with a toolbox of algorithms for solving convex optimization models
- Be able to choose an algorithm for solving a given convex optimization model and be aware of the algorithmâ€™s limitations
- Become familiar with many practical issues with convex optimization
- Have improved oral and written communication skills through course project and activities

Logistics

In addition to pre-class assignments and in-class activities, the course will have problem sets and one small-group project.

Problem Sets

There will be (roughly) six problem sets. The problem sets consist of a combination of theoretical and application-based exercises, with an emphasis on (first) understanding the methods we study and (then) applying them.

Group Project

In addition to problem sets, there will be one group project on applications of convex optimization in the second half of the semester. Students are expected to implement algorithms and use computer programs to solve larger-scale optimization problems in a chosen domain.

Quizzes

There will be two in-class quizzes. The tentative dates are listed on the Schedule page.

Late Policy

Each student will receive 2 late days over the semester, each allowing the student to turn in homework 24 hours late without penalty. You may only use **1 late day per assignment.** Late days may not be allowed on certain assignments preceding quizzes and/or the project. In cases of medical or other emergencies which interfere with your work, have your Resident Dean contact the instructor.

Grading

Your grade will be calculated as a weighted average of your scores on participation (pre-reading and in-class activities), problem sets, group project, and two in-class quizzes. The percentage breakdown is 25% participation, 40% problem sets, 15% group projects, and 20% for the quizzes. There will not be a final exam.

Collaboration Policy

All problem sets should be written up individually unless otherwise instructed. All group projects are to be completed in teams.

Covid Policy

It's important to take care of yourself and people around you. Try to eat well, get enough sleep, be active and wash hands often. If you can't come to class, either because you don't feel well or you need to quarantine, please (1) let the teaching staff know and (2) (whenever relevant) let your team members know in advance. The teaching staff will provide missed course materials to you and will be happy to meet virtually with you to help you understand the materials.