CSCI 1951-G – Optimization Methods in Finance

Syllabus

January 23, 2018

Welcome to CSCI 1951-G, Optimization Methods in Finance! This course has been given only once previously, and we are excited to have you aboard.

Course Information

Meeting Times: Fridays, 2–4.20pm

Classroom Location: CIT 316

Website: `http://cs.brown.edu/courses/cs1951g/`

Mailing List: `cs1951g.2017-18.s@lists.cs.brown.edu`
Subscribe at `https://lists.cs.brown.edu/sympa/info/cs1951g.2017-18.s`

Instructors and TAs Information

Instructor

- **Matteo Riondato**, Visiting Assistant Professor, `matteo@cs.brown.edu`.
  Office Hours: by email appointment on Fridays in CIT 317.

Teaching Assistant

- **Won Jun "June" Kang**, Head TA, `cs1951gheadtas@cs.brown.edu`.
  Office Hours: Tuesday, 4pm to 6pm, in CIT 207.

Communication: The best way to get in touch with the staff is to write to `cs1951gtas@cs.brown.edu`: more eyes reading your message imply a higher chance of getting a fast reply. All communications from the staff will be sent to the course mailing list, so make sure to subscribe to it (see above).

Course Description

The task of efficiently finding the maximum or the minimum value of a function subject to constraints on its domain has classically be of fundamental importance in many areas of computer science (e.g., machine learning), engineering, and logistics. In the last fifty years, optimization

became the cornerstone of computational finance, where the need for efficient methods becomes as extreme as the speed of investing.

In this course we introduce the main classes of optimization problems (linear, quadratic, convex, integer, stochastic, and robust) and the algorithms to efficiently compute the optimum in each case.

We ground the theory into practice by discussing, for each optimization class, one or more applications to problems from computational finance, from cash management to portfolio optimization, to the construction of index funds.

Prerequisites: CSCI 1450 or APMA 1650, and CSCI 1570

Course Goals and Objectives

The main goal of this course is to learn about the main classes of optimization problems and theory and algorithms used to solve such problems. The second goal is to become familiar with some financial instruments and problems from computational finance and understand how to model and solve them using optimization. The third goal is to learn how to use some popular optimization software packages and modeling languages. On a higher level, the course also aims at developing algorithmic intuition, mathematical and scientific writing skills, and theory-to-practice transfer skills.

Course Materials

Textbook: G. Cornuejols, R. Tütüncü, *Optimization Methods in Finance*, Cambridge University Press, 2007.

Additional Materials:

- The textbook *Convex Optimization*, by S. Boyd and L. Vandenberghe can be used for additional readings on some optimization topics. It is available for free from `https://web.stanford.edu/~boyd/cvxbook/`.
- Additional notes on some topics (e.g., modeling languages, CPLEX) will be published on the course website.
- There is plenty of additional materials on optimization and on finance on the Web.

Assessment

Weekly homework assignments are released after each class on the course website. The assignments include both theoretical and programming exercises. The midterm is an assignment on all materials covered in the first half of the course. The final is a take-home assignment on all covered materials.

You will be evaluated on the level of detail and rigor in your homework answers. More details are often better than fewer, but too many hinder readability. If you give the right amount of details, we will not misunderstand what you say, and you will get better corrections. Writing clearly is an essential skill for a scientist. For the programming assignment, we care about correctness more than we care about efficiency, but a code that it is too slow is a code that is not correctly implemented. We will almost never look at your code, but we will run it.

Overall course grades will be assigned as follows:

- 60% homeworks (including midterm),
- 40% final.

Expectation of Students

Class Participation

An active participation by the students helps creating a supportive and inclusive environment for learning and teaching.

No question is stupid: if you have one, it is likely that others in the class do, so please ask it. Everything can be explained multiple times, just ask. The more you ask, the more the instructors can adapt the course to the students needs and pace, and the more everybody learns. This is especially important in a course that is offered for the first time.

The instructors may not have all answers to all questions on the top of their heads at all times. If they did, they would be teaching theology in Paris.

Collaboration Policy

You may discuss non-programming homework assignments in groups. However, each student must write up their solutions independently, and do any required programming independently. If you discuss the assignment with another student, list their names on the front page of your solutions. You may not directly copy solutions from other students, or from materials distributed in previous versions of this or other courses, or from any other material available online. You may not make your solutions available to other students: files in your home directory may not be world-readable, and you may not post your solutions to public websites.

No collaboration or discussion of any kind is allowed for the midterm and the final.

Late Submission Policy

Homework are due on Fridays by 1.59pm. You may submit up to *one* late assignment without penalty by Sunday at 23.59pm, except for the midterm and the final which must be submitted by the given deadline. For each subsequent late assignment, 20 points (out of a maximum of 100) will be deducted from the overall score. *Exceptions to this policy are only given in very unusual circumstances, and any extensions must be requested at least two days before the normal deadline, by e-mail to the instructors.*

Academic Support

Please inform Matteo (`matteo@cs.brown.edu`) if you have a disability or other condition that might require some modification of any of these course procedures. You may speak with Matteo after class or during office hours. For more information, contact Students and Employee Accessibility Services at 401-863-9588 or `SEAS@brown.edu`.

Course Outline

The following is a non-exhaustive list of topics covered in the course, with a tentative schedule. Both the topics and the schedule may be subject to change.

Linear Programming: duality, geometry of optimal solution, the simplex and the dual simplex algorithm, short-term financing and asset pricing. *Weeks 1 to 4*

Integer Programming: mixed integer linear programming, branch and bound, cutting planes, constructing an index fund. *Week 4 to 6*

Non-Linear Programming: Newton's method, steepest descent, generalized reduced gradient, volatility estimation. *Week 6 to 8*

Quadratic Programming: Interior point methods, portfolio optimization: mean-variance optimization and maximizing the Sharpe ratio. *Week 8 to 10*

Stochastic Programming: Two stage problems, risk measures, asset/liability management. *Week 10 to 12*

Robust Optimization Uncertainty sets, robust portfolio selection *Week 12 to 13*