Convex Optimization Project

Spring 2024

1 Description

The goal of this project is to apply convex optimization in a problem or topic of your interest. You are free to propose your own topic; you should think about it early, discuss with your research adviser or course instructor as necessary. Your project can either be a **new research problem** formulated to fit in a course project, or an **in-depth review** of optimization formulations and techniques in a specific research topic. In either category, your project should include to various degrees the components of (1) problem formulation, (2) analysis of the optimal solution or how convex optimization can be used in your formulation, and (3) implementation of algorithm(s). We provide more details on each type of projects below. You are to work in a group of **no more than 2 people**.

1.1 A new research problem

You will be formulating a new optimization problem based on your research. You will need to provide some background on the research topic and show how the research question(s) can be formulated into an optimization problem. The problem may not be convex to begin with, which is fine. The next step is to discuss how you can apply convex optimization to your problem and provide some analysis of the optimal solutions. For example, if your formulation is not convex, can you use a convex formulation to bound it; if so, how tight is the bound? If your formulation is convex, discuss the optimal solution, meaningful insights you can gain from applying duality theory and analyzing the optimality conditions. Lastly, you need to implement a simple numerical algorithm to solve your proposed problem, or a simplified version of it (so that it can done within a course project), and compared with existing results on the same topic if available. The ideal outcome of this type of project is a conference paper, ready to go at the end of the semester.

1.2 A in-depth review of a topic

You pick a topic and show how convex optimization has been applied in this topic in an in-depth review. You will need to provide some background on the topic, show different problem formulations then discuss how different optimization techniques have been used to solve the problem. Your discussion must include the use of convex optimization in both analysis and algorithms. That is, you cannot pick a topic that only has heuristic, nonconvex optimization, but you can choose a topic that has both convex and nonconvex optimizations and compare them. Your review should be a comprehensive synthesis of existing formulations and results, clearly show the progression in optimization approaches. You also need to have a component of numerical algorithms by implementing some of these results. Your implementation, however, should be more than a mere reproduction of these results. You need to have some degree of novelty, for example, design and implement a better algorithm to solve the problem, or compare different algorithms, discuss different approaches. The ideal outcome of this type of project is a tutorial paper, for students and researchers who are interested to learn about how convex optimization is applied in a specific topic.

2 Project Schedule

- Project proposal (1 page, with 5-6 key reference papers): **Apr. 24**
- Problem formulation (5-7 pages single-column double-space): **May 8**
- Presentation (15-20 minutes): **Jun. 12 (tentative)**

- Report and code (5 pages double-column single-space, IEEE conference format): **Jun. 12 (tentative)**

Proposal: Your proposal should give a brief introduction of your chosen topic, describe the problem and the proposed approach, and include a list of most relevant reference. The reference list should include at least 5-6 key papers (either conference or journal paper), books do not count. The proposal length is 1 page. We can provide feedback on your proposal.

Formulation: This is a detailed description of your problem, including background, assumptions, problem setup and the formulation of an optimization problem. You can also include some intitial analysis of the problem. This formulation would serve as the first few sections of your report. The length is 5-7 pages single-column double-space. You are **strongly encouraged** to use Latex and the IEEEtran template.

Presentation: You will present the project to the professor, TA, and your peers. Your presentation should give a clear introduction of the topic, problem formulation, highlights of analysis, algorithm and numerical optimization results, without going into excessive details. You should aim for a 15 minute talk plus 3-5 minutes of questions and answers at the end. Extra credit will be given to those students who asked interesting questions to the presenter. **You can use Latex and the beamer template so that the equations from your formulation can be directly transfer into your presentation**.

Report and code: Your report should give the detail of the problem, analysis, algorithm and numerical results in the form of an IEEE conference paper, double-column single-space. The report length is 5 pages. Please do not include codes in your report. Long derivation can be included in an appendix as an extra part to the report. You are **strongly encouraged** to use Latex and the IEEEtran template. Coding should be done on Matlab and should be able to run on Matlab 2023b.

Submission and grading: **The report and code should be uploaded to E3 no later than 23:59:59 of the due date stated above in the form of a zip file**. The zip file should include a main directory with your student IDs as the name. For instance, if there are two people in your group, then the name of the directory should contain the IDs of both students with an underscore separating the ID numbers, i.e. `12345_54321`. Inside the main directory should contain a "doc" and "code" directory where you will place your documents (tex, pdf, and presentation file) and code, respectively. **You also need to send, via email, your presentation files (the source files (pptx, tex, ...), and pdf) to the instructor and TA before noon on the date of the oral presentation. You also need to print out hardcopies of your presentation file for the instructor and TA in 4-in-1 double-sided landscape format from pdf (not pptx) before your presentation.**

Your project will be graded based on the technical depth, the clarity of your problem formulation and solution. Both analysis and algorithm components will be considered. Novelty will be highly rewarded. Report presentation (organization, English usage, readability and clarity) is also important and makes up a part of the grade. Accuracy and efficiency of your Matlab implementation will also be counted. **Every attendees will be REQUIRED to ask at least one "non-obvious" technical question to the presenter, otherwise points will be deducted for your own presentation.**