Convex Optimization Project

Spring 2014

1 Description

The goal of this project is for you 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 advisor or the 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 used in a specific topic. In either category, your project should include to various degrees the components of problem formulation, analysis of the optimal solution or how convex optimization can be used in your formulation, and implementation of algorithm(s). We provide more details on each type of projects below.

1.1 A new research problem

In this case, you will be formulating an optimization problem based on your research. You will need to provide some background on the topic of your research 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 be done within a course project), and compared with exiting 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.

Some examples of this type of projects are

- Resource allocation in a communication system
- Network performance and resource optimization
- Rank constrained problems

1.2 An in-depth review of a topic

In this case, you pick a topic and show how convex optimization has been applied in this topic. This review will be in-depth and of a pedagogical nature. 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 problems. Your discussion must include the use of convex optimization in both analysis and algorithms. That is to say, you cannot pick a topic that only has heuristic, non-convex optimization; but you can choose a topic that has both convex and non-convex optimization 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 not be 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 to be given to other students and researchers who are interested to learn about how convex optimization is applied in a specific topic. It could also serve as an example of application of convex optimization for this course in the future.

Some examples of this type of projects are

- Digital filter design
- Beamforming and transmitter design in communication
- Estimation and optimal control

2 Project schedule

- Project proposal (1 page): **February 26**
- Presentation (10-12 minutes): **week of April 21** (may not be on a class day)
- Project report: **May 2**

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 references. The length is 1 page. We will provide feedback on your proposal, but the proposal is not graded.

Presentation: Each team will present the project to the instructor and your peers. If you work in team, both members of the team will need to present. 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 10 minute talk plus 2-3 minutes of questions and answers at the end.

Report: Your report should give details of the problem, analysis, algorithm and results in the form of an IEEE conference paper, double column single space. The length is 5 pages. Do not include codes in your report. Any long derivation can be included in an appendix as an extra part to the report.

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. Pay attention also to the presentation of your report, if I cannot clearly understand what you write it will affect your grade.