SI151A: Convex Optimization and Its Applications in Information Science
Course Projects, Fall 2024

(Instructor: Yuanming Shi)

Projects can either be individual or in teams of size up to ***two*** students. In the team case, your write-ups must clearly describe who contributed which parts of the project, and the contributions should be **roughly equal**. Obviously, it is expected that a team project makes more progress than an individual project, since you have multiple people working on it.

Projects will be evaluated based on a combination of:

1) **Proposal** (due the end of 13-th week): Submit a short report (no more than 1 page) stating the papers you plan to survey or the research problems that you plan to work on. Describe why they are important or interesting, and provide some appropriate references. If you elect to do original research, please do not propose an overly ambitious project that cannot be completed by the end of the semester. Focus on the simplest scenarios that can capture the key issues you'd like to address.
2) **A written report** (due the end of 16-th week): you are expected to submit a final project report (up to 8 pages with unlimited appendix and reference to summarize your findings and contributions. **Source codes also should be submitted**.

Suggestions for technical write-ups

This is an important part of the learning exercise. Please spend time on your write-up so that your work is well-motivated, described precisely, and your results/conclusions are clear. Some ideas to keep in mind:

- The introduction should set up the problem (e.g., why is it interesting? important?) and provide some context for what work has been done in the past (e.g., what is known? what is open? what are deficiencies of current approaches?)
- The methods/results section should describe clearly what you did (e.g., enough details for someone to re-implement what you did, if needed), provide some summary tables or figures that illustrate your results, along with some descriptive interpretation.
- The discussion or conclusion section should summarize what you learned, what worked well or what didn't, what you might do if you were to continue to work on this project, and so on.

Topics:

We will provide a list of related papers on convex/nonconvex optimization in Blackboard. The literature review should involve in-depth summaries and exposition of one of these papers. You should read a number of papers in your selected topic, teach yourself, summarize your findings, provide optimization algorithms, numerical experiments and software implementation. The detailed requirements are presented as follows:

- Select one of the listed topics (detailed requirements/guidelines for each paper will be introduced during the class)
- Provide the optimization problem formulation, background, motivation, etc.

- Describe the optimization algorithms (you are encouraged to try new algorithms different from your selected paper)
- Software implementation for large-scale optimization algorithms
- Provide numerical experiments (you should not only reproduce some numerical results in your selected paper but also do more experiments different from the selected paper)

You have the freedom to select a paper of your own interest (especially more practical papers), upon the instructors' approval (send email (shiym@shanghaitech.edu.cn) or by appointments).

Reference:

Part I: Generative AI for Optimization

[1] "Diffusion Models for Black-Box Optimization," ICML 2023
[2] "A Diffusion Model Framework for Unsupervised Neural Combinatorial Optimization," ICML 2024
[3] "OptiMUS: Scalable Optimization Modeling with (MI)LP Solvers and Large Language Models," ICML 2024

Part II: Sparse and Low-Rank Optimization

[1] "DC formulations and algorithms for sparse optimization problems." Gotoh, Jun-ya, Akiko Takeda, and Katsuya Tono.
[2] "Pretraining and the Lasso" by Mert Pilanci
[3] "Neural Spectrahedra and Semidefinite Lifts: Global Convex Optimization of Degree-Two Polynomial Activation Neural Networks in Polynomial-Time," Mathematical Programming 2024