ECE569/AI539 Convex Optimization - Course Project

Fall 2021
School of Electrical Engineering and Computer Science
Oregon State Univeristy

Due: Friday, Final Exam Week

1 General Information

The course project consists of a couple of things:

- A project report. The report is expected to contain abstract, introduction, problem formulation, algorithm (even you use `cvx`), simulation/experiement results, and references. In short, all the things that are contained in a technical paper are required to be written in the report.
- **Reproducible Code**: Submission of the source code, which can be (easily) tested and read by me (please put clear comments in your codes). If the data that you work with is too large or confidential, you may make a demo with synthetic data. Using code posted by authors of research papers is discouraged.
- **Template**: The LaTex template is restricted to the NeurIP 2021 template `https://nips.cc/Conferences/2021/PaperInformation/StyleFiles`. Other templates are not accepted.
- **Page Limitation**: The report should be no longer than 8 pages. References can go to the 9th page. In short, follow the NeuriPS style.

The project report should address either of the following:

1. Read and understand a technical paper (some examples will be given in the next section). Write a summary about the background, the rationale behind the problem formulation, and how the optimization algorithm works. Implement the algorithm and apply it to some existing and *new scenarios*. Here, 'new' means that something was not included in the original paper. For example, if one topic mining paper applies their algorithm to a dataset, you may try another dataset. When you submit the project, highlight this *new* part and clearly state what is new. You are also encouraged to survey the related area and make your comments. Simply copying and pasting sentences from the original paper(s) will not be appreciated.
2. Propose new ideas and prototype them. Introduce the background and the problem. Introduce the state of the art. Propose your idea, formulate it as an optimization problem, and use simulations to support your idea. This could be risky given the short duration of the term. But if it works, you may enjoy high scores and potential publications in the future.

You may propose something related to your research, but make sure that you discuss with your advisors to see if the contents are confidential. You may also make an appointment with me to see if the proposed idea is feasible in one month.

2 Technical Papers

In this section, we list a series of papers that heavily use optimization tools to handle their engineering problems. You can pick one or more to summarize and replicate their results. Please note that the following are just some examples. **You are not restricted to this set of papers**. You may pick papers that you like from outside of the following pool and write report about those papers. You are also not restricted to one direction. For example, Sec. 2.1 and Sec. 2.2 are heavily related. If you could draw connections between the two and make comments, that would be appreciated.

Coding: A part of the report should be simulations/experiments with Matlab/Python implementations. Note that some authors of the following papers post their Matlab/python code online. It is not recommended to just download the code and run for your report. You may refer to these publicly available code, but implementing by yourself may make your final project much stronger. If you have to use online available code, make sure that you clear declare the source and cite the reference.

2.1 Convex Geometry and Blind Separation

- T.-H. Chan, W.-K. Ma, C-.Y. Chi, and Y. Wang, "A convex analysis framework for blind separation of non-negative sources," IEEE Trans. Signal Process., vol. 56, no. 10, pp. 5120-5134, Oct. 2008.
- T.-H. Chan, C.-Y. Chi, Y.-M. Huang, and W.-K. Ma, "A convex analysis based minimum-volume enclosing simplex algorithm for hyperspectral unmixing," IEEE Trans. Signal Process., vol. 57, no. 11, pp. 4418-4432, Nov 2009.

2.2 Convex Geometry and Topic Mining

- K. Huang, X. Fu, and N. D. Sidiropoulos, "Anchor-Free Correlated Topic Modeling: Identifiability and Algorithm", Advances in Neural Information Processing Systems (NIPS 2016), Dec. 2016, Barcelona, Spain.
- Nicolas Gillis, "Robustness analysis of Hottopixx, a linear programming model for factoring nonnegative matrices." SIAM Journal on Matrix Analysis and Applications 34.3 (2013): 1189-1212.
- Abhishek Kumar,Vikas Sindhwani, and Prabhanjan Kambadur, "Fast conical hull algorithms for near-separable non-negative matrix factorization." Proceedings of the 30th International Conference on Machine Learning (ICML-13). 2013.
- Mizutani, Tomohiko. "Ellipsoidal rounding for nonnegative matrix factorization under noisy separability." Journal of Machine Learning Research 15.1 (2014): 1011-1039.

2.3 Convex Optimization and Support Vector Machines

- Lanckriet, G. R., Cristianini, N., Bartlett, P., Ghaoui, L. E., and Jordan, M. I. "Learning the kernel matrix with semidefinite programming," Journal of Machine learning research, 5(Jan), 2004, 27-72.
- Rie Johnson and Tong Zhang. "Accelerating stochastic gradient descent using predictive variance reduction." Advances in neural information processing systems. 2013.
- Cho-Jui Hsieh, Kai-Wei Chang, Chih-Jen Lin, S. Sathiya Keerthi, and Sellamanickam Sundararajan. "A dual coordinate descent method for large-scale linear SVM." In Proceedings of the 25th international conference on Machine learning, pp. 408-415. ACM, 2008.

2.4 Recommender Systems

- Emmanuel J. Candés and Benjamin Recht "Exact matrix completion via convex optimization," Foundations of Computational mathematics 9.6 (2009): 717.
- Moritz Hardt, "Understanding alternating minimization for matrix completion." Foundations of Computer Science (FOCS), 2014 IEEE 55th Annual Symposium on. IEEE, 2014.

2.5 Sparse Optimization and Low-Rank Optimization

- Amir Beck and Marc Teboulle. "A fast iterative shrinkage-thresholding algorithm for linear inverse problems," SIAM journal on imaging sciences 2.1 (2009): 183-202.
- Rahul Garg and Rohit Khandekar, "Gradient descent with sparsification: an iterative algorithm for sparse recovery with restricted isometry property," Proceedings of the 26th Annual International Conference on Machine Learning. ACM, 2009.
- E. Candés, X. Li, Y. Ma, and J. Wright (2011). "Robust principal component analysis?". Journal of the ACM (JACM), 58(3), 11.
- Shai Shalev-Shwartz, Alon Gonen, and Ohad Shamir. "Large-scale convex minimization with a low-rank constraint." arXiv preprint arXiv:1106.1622 (2011).
- Martin Jaggi, "Revisiting Frank-Wolfe: Projection-Free Sparse Convex Optimization." ICML (1). 2013.

2.6 Signal Processing and Communications

- Nikos D. Sidiropoulos, Timothy N. Davidson, and Zhi-Quan Luo. "Transmit beamforming for physical-layer multicasting." IEEE Transactions on Signal Processing 54.6 (2006): 2239-2251.
- Dmitry Malioutov, Mjdat Cetin, and Alan S. Willsky. "A sparse signal reconstruction perspective for source localization with sensor arrays." IEEE transactions on signal processing 53, no. 8 (2005): 3010-3022.
- Petre Stoica, Zhisong Wang, and Jian Li. "Robust Capon beamforming." IEEE Signal Processing Letters 10.6 (2003): 172-175.

2.7 Tensor Decomposition

- K. Huang, N. D. Sidiropoulos, and A. P. Liavas, "A flexible and efficient algorithmic framework for constrained matrix and tensor factorization," IEEE Trans. Signal Process., vol. 64, no. 19, pp. 50525065, 2016.
- Y. Xu and W. Yin, "A block coordinate descent method for regularized multiconvex optimization with applications to nonnegative tensor factorization and completion," SIAM Journal on imaging sciences, vol. 6, no. 3, pp. 1758–1789, 2013.

3 Academic Misconduct

We treat academic misconduct seriously. Please refer to the university policy for pertinent matters (see `https://studentlife.oregonstate.edu/studentconduct/academicmisconduct`). Some activities are particularly not acceptable, e.g.,

- Using/re-using reports from previous years,
- using your ongoing research reports as course reports without clearly stating the correlation and difference (the course report is supposed to be a separate effort; dual use of reports is not allowed),
- submitting similar reports of your peers' (this is supposed to be individual work and thus highly correlated reports are prohibited),
- copying and pasting sentences/paragraphs/figures from the published technical papers that your report is based on,
- directly downloading code from the internet without declaring/citing the source,
- or altering online available code to claim coding contribution.

The above are considered violation of university policy. The activities will be reported to the college of engineering (COE), and will be handled by a committee.