ECE599 / AI539 Convex Optimization - Homework 3

Fall 2022
School of Electrical Engineering and Computer Science
Oregon State Univeristy

Due: Nov. 25, 2022

Attention: For all the algorithms that you design in this homework, first derive the algorithms and write down the pseudo code (i.e., the rule that you use to produce the iterates) as we do in the class. Also pay attention to stopping criteria. Submit the written pseudo code with the coding scripts.

Q1 Consider the classification problem in Homework 2. Download the datasets `train_separable.mat` and `test_separable.mat` from the course website. Download `CVX` from `http://cvxr.com/cvx/` (or `http://www.cvxpy.org/en/latest/` if you use Python) and learn how to use it. Implement the following using `CVX`.

a) Apply the C-Hull formulation to train a classifer, i.e.,

$$\begin{aligned} \text{minimize}_{u,v} \ & \|Au - Bv\|_2^2 \\ \text{subject to } & 1^T u = 1, \ u \succeq 0 \\ & 1^T v = 1, \ v \succeq 0 \end{aligned}$$

Visualize the training data together with the classifier. Also visualize the testing data and the classifier in another figure, and report the classification error on the testing data using the true labels provided in `test_separable.mat` . (15%)

d) Repeat the above for `train_overlap.mat` and `test_overlap.mat` using the reduced C-Hull, i.e.,

$$\begin{aligned} \text{minimize}_{u,v} \ & \|Au - Bv\|_2^2 \\ \text{subject to } & \mathbf{1}^T u = 1, \ d\mathbf{1} \succeq u \succeq 0 \\ & \mathbf{1}^T v = 1, \ d\mathbf{1} \succeq v \succeq 0. \end{aligned}$$

Report the classification error on the testing data **using an appropriate** d. (15%)

(Please also submit your scripts. In case that your do not know what is C-Hull, check out the paper by Kristin P. Bennett, and Erin J. Bredensteiner, "**Duality and geometry in SVM classifiers**," ICML 2000. In addition, for background of classification, check out the slides of **Lecture 1**.)

Q2 Under the same setting of **Q1**, do the following:

(a) Implement C-Hull and Reduced C-Hull using projected gradient. Do the same visualization as in Q1. (15%)

(b) Repeat the above using Nesterov's acceleration. (15%)

(check out Beck, Amir, and Marc Teboulle. "A fast iterative shrinkage-thresholding algorithm for linear inverse problems." SIAM journal on imaging sciences 2.1 (2009): 183-202.)

Q3 Under the same setting of **Q1**, implement C-Hull and Reduced C-Hull using ADMM. Do the same visualization as in Q1. (30%)

(check out: Boyd, Stephen, Neal Parikh, and Eric Chu. Distributed optimization and statistical learning via the alternating direction method of multipliers. Now Publishers Inc, 2011.)

Q4. Plot an "iteration v.s. objective value" figure for the training process. Compare all the algorithms that you implemented in this figure. In addition, plot a "time v.s. objective value" figure using all the algorithms. (10%)