

# EE 5239 Optimization Homework 3 Cover Sheet

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- Date assigned: **Tuesday** 10/01/2019
- Date due: **Sunday** 10/13/2019, midnight
- This cover sheet must be signed and submitted along with the homework answers on additional sheets.
- By submitting this homework with my name affixed above,
  - I understand that late homework will not be accepted,
  - I acknowledge that I am aware of the University's policy concerning academic misconduct (appended below),
  - I attest that the work I am submitting for this homework assignment is solely my own, and
  - I understand that suspiciously similar homework submitted by multiple individuals will be reported to the Dean of Students Office for investigation.
- Academic Misconduct in any form is in violation of the University's Student Disciplinary Regulations and will not be tolerated. This includes, but is not limited to: copying or sharing answers on tests or assignments, plagiarism, having someone else do your academic work or working with someone on homework when not permitted to do so by the instructor. Depending on the act, a student could receive an F grade on the test/assignment, F grade for the course, and could be suspended or expelled from the University.

In this homework, we will get familiarized with the gradient based algorithms we learned so far, and build a model for classifying the hand writing digits. The objective is to give you some insights on the practical performance of different gradient-based algorithms. Also you should learn to load the data files and play with them. The data sets are available at the course web site.

1. (20 points) **Running Algorithm on a randomly generated problem**

Perform the following steps :

- (a) Randomly generate a matrix  $\mathbf{A}$  of dimension  $50 \times 10$ ; generate a vector  $\mathbf{b}$  of the size  $50 \times 1$ .
- (b) Use the steepest descent method to solve the following optimization problem

$$\min_{\mathbf{x}} \frac{1}{2} \|\mathbf{Ax} - \mathbf{b}\|^2,$$

You need to use a few different choices of the stepsizes, and plot evolution of the objective function for each stepsize (y-axis objective, x-axis iteration counter); For those choices that make the algorithm converge, validate the optimality of the solution. You will need to try the following stepsize rules of steepest descent:

- Constant stepsize (you will observe that when stepsize is too big, then the algorithm will diverge).
- Diminishing stepsizes; Try  $\alpha_r = 1/r$ ,  $\alpha_r = 1/r^2$ ,  $\alpha_r = 1/\sqrt{r}$  (where  $r$  is the iteration number), and see the difference.
- Armijo stepsize selection rule.

2. (80 points) **Running Algorithm on Data Set**

Utilizing the two features that are provided by the data set, perform linear regression on the training data set. You can define your own tasks, for example separating digit “1” and “5”, or separating “1” and the rest.

Your task is to first build a linear regression model for this problem (see the notes attached to this document), and use your favorite scientific computing software to implement the following algorithms

- Steepest Descent using constant stepsize rule
- Steepest Descent using diminishing stepsize rule
- Steepest Descent use Armijo rule

**The requirement:** A report needs to be written on the work that has been performed. For each problem above, important parts that need to be covered are: 1) description of the problem you are solving; 2) description of the algorithm that solves the model; 4) description of the results; 5) analysis of the performance of different algorithms and conclusion.

For item 4) and 5), the convergence speed of the algorithm (in terms of the objective reduction during training) need to be demonstrated and compared. Different parameter setup needs to be tried and compared (for example, for steepest descent with constant stepsize, you can compare the stepsizes used and plot the performance of different cases). In item 5), briefly discuss why you think different algorithms behave differently.

**Note:** Please put your codes in a zipped folder and upload to Moodle; Also upload (in a separate pdf file outside the .zip file) your report.

**The data sets:** Please download from the course web site the “handwriting data.zip” folder. Please first read the “info.text” to get an idea of the overall data set. The data file that you are going to use in this assignment is “feature\_train.txt” (training data). As have been explained before, here two specific features have already been computed for you (“symmetry” and “intensity”), for each of the data point.