CSE 417A: Homework 3

Due: October 6, 2015

Notes:

- Please keep in mind the collaboration policy as specified in the course syllabus. If you discuss questions with others you must write their names on your submission, and if you use any outside resources you must reference them. Do not look at each others’ writeups, including code.

- Instructions for how to get files from the SVN repository are available on the course website and on Piazza.

- Homework (in hardcopy) is due at the beginning of lecture. In addition, your code submissions must also be timestamped before lecture begins.

- Please comment your code properly.

- There are 5 problems on 2 pages in this homework.

- Keep in mind that problems and exercises are distinct in LFD. Question 3 is an exercise. 4 and 5 are problems.

Problems:

1. (45 points) Read the instructions on the course website (or Piazza) for how to check out files from the SVN repository set up for this assignment. The files logistic_reg.m and find_test_error.m are just function headers that need to be filled in. find_test_error should encode a function that, given as inputs a weight vector $w$, a data matrix $X$ and a vector of true labels $y$ (in the formats defined in the header), returns the classification error of $w$ on the data (assuming that the classifier applies a threshold at 0 to the dot product of $w$ and a feature vector $x$ (augmented with a 1 in the first position in the vector to allow for a constant or bias term). logistic_reg should encode a gradient descent algorithm for learning a logistic regression model. Given the data matrix $X$, the true labels $y$, and the maximum number of iterations to run for max_its, as inputs, it should return a weight vector $w$ and the training set error $E_{in}$ as defined in class. Use a learning rate $\eta = 10^{-5}$ and automatically terminate the algorithm if the magnitude of each term in the gradient is below $10^{-3}$ at any step.

   - Implement the functions in the two files.
   - Read more about the “Cleveland” dataset we’ll be using here: https://archive.ics.uci.edu/ml/datasets/Heart+Disease
• Learn a logistic regression model on the data in cleveland.train (be careful about the fact that the classes are 0/1 – you should convert them to −1/+1 so that everything we’ve done in class is still valid). Apply the model to classify the data (using a probability of 0.5 as the threshold) in cleveland.test. In your writeup, report \( E_{in} \) as well as the classification error on both the training and test data when using three different bounds on the maximum number of iterations: ten thousand, one hundred thousand, and one million. What can you say about the generalization properties of the model?

• Now train and test a logistic regression model using the inbuilt matlab function glmfit. Compare the results with the best ones you achieved and also compare the time taken to achieve the results.

**Note on the autograder:** The autograder tests the correctness of your gradient descent logistic regression algorithm. It will randomly generate a data set and then run both your logistic_reg.m and our code to get one classifier from each of them. If the L2 norm of the diff vector of two classifiers is larger than \( 10^{-5} \), autograder will report an error message. We will run the above comparison 5 times and only after you pass all five comparisons will we send you a “congratulations” message.

2. (20 points) Download the handwritten digits dataset from [http://amlbook.com/support.html](http://amlbook.com/support.html) and familiarize yourself with the data. The matlab code for plotting images is also a useful tool to get acquainted with. Now, we will be working on the problem of deciding whether or not an image is a “1”, using both the raw data (zip.train and zip.test) and another version of the dataset that extracts only two features, symmetry and intensity (features.train and features.test). Write a matlab script (which you will submit along with your code for Question 1) called question2.m that does the following:

- Loads the data in zip.train and trains a logistic regression model using matlab’s glmfit function for predicting the probability that an image is a “1” or not on that data.

- Applies the model to classify the data (using a probability of 0.5 as the threshold) in both zip.train and zip.test (for the same problem of classifying whether an image is a “1” or not) and reports the classification error on both the training and test data.

- Repeats the above two steps for features.train and features.test

In addition to submitting your code, in your writeup, report the training and test set classification errors for both datasets. Interpret your results in the context of the generalization error of the model and the dimensionality of the data. Which model generalizes better? Are you sufficiently convinced by this one experiment? If not, describe another one you could do to become more confident in your interpretation.

3. (10 points) LFD Exercise 3.7
4. (15 points) LFD Problem 3.4
5. (10 points) LFD Problem 3.16