Engineering and Applied Science Programs for Professionals
Whiting School of Engineering
Johns Hopkins University
685.621 Foundations of Algorithms
Programming Assignment 2
Assigned with Module 7
Due at the end of Module 14

Total Points 100/100

In this programing assignment students are to apply Machine Learning techniques to the MNIST data set and build an AI for the game of Tic-Tac-Toe using Game Theory techniques. This assignment is to be implemented by the individual student (i.e., it is not collaborative). You may use MATLAB, JAVA, Python or R as your programming language. Please follow the requirements provided in the Programming Assignment Guideline.

Programming (non-collaborative)

Problem 1 - Machine Learning

40 Points Total 5 Points Each

In this problem the features generated from HW2 for the numerical data set are to be used. This is the starting point for this problem. A minimum of 10,000 observations need to be used in the problem. A data set developed with the numericalFeatureGeneratorExample.m will also be provided if needed. The updated data is provide as an Excel file with 42,000 observations and 60 features, 20 from each direction. In this assignment data processing and machine learning techniques need to be implemented as follows:

1. [2.5 points] Rank the features to determine which are the top features you select, recommended using the top 10 features. Please provide an analysis of why the specific top features were selected. This will be your new data set used for the remainder of the problem.

2. [5 points] Perform Feature Preprocessing

   (a) [2.5 points] Use a normalization method to normalize your data.

   (b) [2.5 points]Use an outlier removal method to remove any outliers for the data set you will be processing. Please provide an analysis of why the outliers were removed.

3. [20 points] Using the following Machine Learning (ML) techniques:

   (a) [5 points] Bayes Classifier

   (b) [5 points] Either Fisher Linear Discriminant (Linear Discriminant Analysis) or Parzen Window (Gaussian kernel)

   (c) [5 points] Either RBFNN or PNN (assume Gaussian kernel)

   (d) [5 points] Support Vector Machine (kernel of your choice)

   Please provide for each of the above methods (a - d) the classification accuracy.

4. [7.5 points] Use 5-fold cross validation (see Figure 1) on three different combinations from normalization, outlier removal and ML.

5. [5 points] Provide an analysis of your results, the analysis should indicate what combination from the above methods gave the best results. The "best results" is considered the highest classification accuracy for the 10 digits.
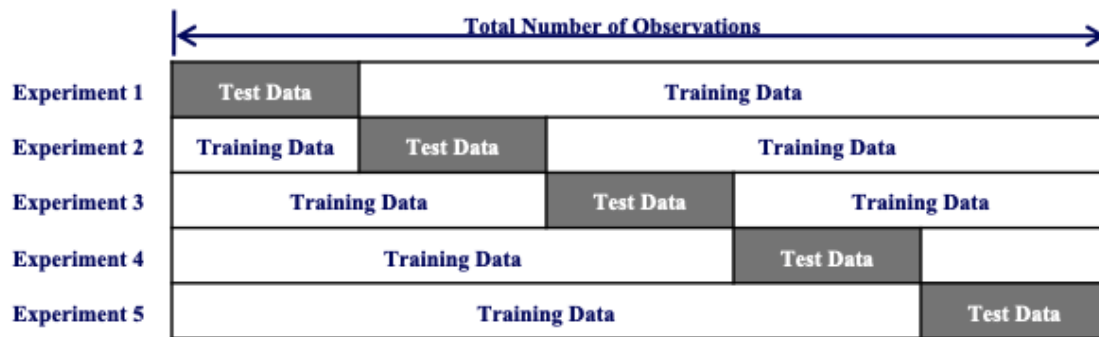
Figure 1: 5-Fold Cross Validation

Problem 2 - Deep Learning

20 Points Total

In this problem us a built-in CNN to process the original MNIST numerical data set. The goal is as follows:

1. Use a built-in CNN to accept the training MNIST data

2. Use the training MNIST data set as inputs to the trained CNN

3. Use the testing MNIST data set as inputs to the trained CNN

4. Analyze the performance results from the output of the CNN for both the training and testing data sets

Problem 3 - Game Theory

40 Points Total

In the tic-tac-toe code provided add the following method to allow an unbeatable AI in your game. Implement to following methods to play against and give the ability to play against.

1. Best Move (Provided)

2. Conditional Statement (PA1)

3. [20 points] Implement one of the following agents:

    (a) Implement Heuristic Alpha Beta Tree Search.
    (b) Implement a Goal Based Agent
    (c) Implement a Utility Based Agent

    The implementation should be used to determine the next move for your intelligent agent.

4. [20 points] The following is to be implemented using either the MiniMax or Alpha Beta algorithm from the Game Theory document to be implemented for the tic-tac-toe game. You will need to alter the provided pseudo code to show how the game board is passed in. This will allow a much smaller code base than your implemented conditional statements. Only one of the following methods needs to be implemented.

(a) MiniMax

(b) Alpha Beta Pruning

Optional Problem 3 - Game Theory

60 Points Total

Using a game implementation (code) of your choice in this problem the game of Chess will be used instead of Tic-Tac-Toe. Give the ability to play against one of the three methods:

1. Make move provided

2. [30 points] Implement one of the following agents:

   (a) Implement Heuristic Alpha Beta Tree Search.

   (b) Implement a Goal Based Agent

   (c) Implement a Utility Based Agent

   The implementation should be used to determine the next move for your intelligent agent.

3. [30 points] The following is to be implemented using either the MiniMax or Alpha Beta algorithm from the Game Theory document to be implemented for the tic-tac-toe game. You will need to alter the provided pseudo code to show how the game board is passed in. This will allow a much smaller code base than your implemented conditional statements. Only one of the following methods needs to be implemented.

   (a) MiniMax

   (b) Alpha Beta Pruning