CSEN 1022 – Machine Learning

# Assignment #2

**(Due on November 30 at mid-night)**
**(This assignment can be done in teams of maximum 2 students – Please include a text files with your names and IDs in the submission)**

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**Problem 1**

You are required to design a Perceptron-based classification algorithm that can recognize scanned images of the 10 digits (0 to 9) provided in the file "Assignment 2 Dataset.zip". The zip file contains two folders: "Train" and "Test". The "Train" folder contains 240 images for each digit, while the "Test" folder contains 20 images for each digit. The images in the "Train" folder should be used to train a classifier for each digit using the method given at the bottom of slide 18 in Lecture 3.pdf. The folder contains a file named "Training Labels.txt" which includes the labels of the 2400 images in order. You need to train the classifiers using each of the following values for the learning rate $\eta = 1, 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}, 10^{-7}, 10^{-8}$ and $10^{-9}$. For all Perceptrons, use an initial weight vector that has 1 as the first component ($w_1$) and the rest are zeros. After the classifiers are trained, test each classifier using the images given in the "Test" folder. The folder also contains a text file named "Test Labels.txt" which include the labels of the 200 images in order.

Deliverables:

- Your code.
- A confusion matrix for each value of $\eta$ showing the number of images of the "Test" folder of each digit that were classified to belong to different digits (For example: Number of images of 0 that were classified as 0, 1, 2, …, 9, and so on for other digits). Convert the confusion matrices to images and save them as "Confusion-x.jpg", where $x$ is absolute value of the power of 10 of $\eta$.

**Important Notes:**

- Limit the number of iterations for training each classifier to only 500, after which the classifier should stop regardless of convergence status.
- Do not use Scikit learn or Scipy built-in functions for the Perceptron classifier. You have to implement your own version of all needed functions. You are allowed to use numpy functions.

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Problem 2

You are required to design a Naïve Bayes-based classification algorithm that can recognize scanned images of the 10 digits (0 to 9) provided in the file "Assignment 2 Dataset.zip". The zip file contains two folders: "Train" and "Test". The "Train" folder contains 240 images for each digit, while the "Test" folder contains 20 images for each digit. The images in the "Train" folder should be used to train a classifier for each digit using the method given at the bottom of slide 18 in Lecture 3.pdf. The folder contains a file named "Training Labels.txt" which includes the labels of the 2400 images in order. Assume that each pixel is distributed according to a Gaussian distribution whose parameters should be identified in the training phase of the Naïve Bayes classifier. After the classifiers are trained, test each classifier using the images given in the "Test" folder. The folder also contains a text file named "Test Labels.txt" which include the labels of the 200 images in order.

Deliverables:
- Your code.
- A confusion matrix showing the number of images of the "Test" folder of each digit that were classified to belong to different digits (For example: Number of images of 0 that were classified as 0, 1, 2, …, 9, and so on for other digits). Convert the confusion matrix to an image and save it as "Confusion-Gauss.jpg".

**Important Notes:**

- It might be useful to divide the value of each pixel by 255 before training the classifier or testing it if the maximum brightness in images is 255.
- If the estimated variance for any pixel is less than 0.01, set it to 0.01 to avoid having NaN or Inf values.