Statistical Machine Learning
Winter 2022
Assignment - 3
Deadline : $5^{th} Apr$ 2022, 11:59PM

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1 Instructions

- You are free to use either python or MATLAB for this assignment.
- You can use inbuilt libraries for Math, plotting, and handling the data (eg. NumPy, Pandas, Matplotlib).
- Usage instructions for other libraries can be found in the question.
- Only (*.py) and (*.m) files should be submitted for code.
- Create a (*.pdf) report explaining your assumptions, approach, results, and any further detail asked in the question.
- You should be able to replicate your results if required.

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2 Question-1[2 Marks]

Use cifar-10 dataset for this questions and perform following tasks.

- Visualize 5 samples from each class in the form of images.
- Apply LDA(use sklearn) on the given dataset.
- Report accuracy and class-wise accuracy for testing dataset.

3 Question-2[2 Marks]

Use MNISTdataset for this questions and perform following tasks.

- Apply PCA(use sklearn) on the given data and set the hyperparameter $n\_components = 15$.
- Apply LDA(use sklearn) on the transformed data.

- Repeat step-1 and step-2 by keeping $n\_components = 8$ and 3.
- Plot accuracy of all three experiments on testing dataset and report which experiments give better result and why?.

4 Question-3[2 Marks]

Use FMNIST(Fashion MNIST)dataset for this questions and perform following tasks.

- Implement FDA on given data for multiple classes from scratch, and find the coefficient vector W.(Note: computation of W will use training samples only.)
- Project the training data (X) using W, and call the projection Y.
- Use the projected data Y to classify the testing samples using LDA (use sklearn).
- Report accuracy and class-wise accuracy.

5 Question-4[2 Marks]

Use MNISTdataset for this questions and perform following tasks.

- Apply PCA(using sklearn) on given data and set $n\_components$ = the best value that you reported from Question-2.
- Apply FDA(Reuse FDA implementation from question-3) on the transformed data which is received from step-1.
- Use the projected data received from step-2 and apply the classifier LDA to classify all testing samples.
- Report accuracy and class-wise accuracy from all testing samples.

6 Question-5 [Theory][2 Marks]

(a) In Rosenblatt' perceptron, the activation is sign function. Suppose we replace it with sigmoid, prove that the update rule for parameters do not change.

(b) Consider the case

$$\phi(\beta, \beta_0) = -\sum_{i=1}^{N} y_i(\beta^\top x_i + \beta_0) \tag{1}$$

where we sum the distance over all the observations. Consider minimizing ϕ subject to L2 norm of β equal to 1 and give the update rule.

7 Question-6[2 Marks]

Consider a scalar input x to the perceptron of Question 5-a. Let the output of this perceptron is fed as an input to Rosenblatt' perceptron. Derive the update rule for all the parameters (including biases for both perceptrons). Using the update rules, write a program to train this network. You can generate a linearly separable synthetic data as per the applicability of perceptron. The derivation of update rule must be submitted as a theory component too. You need to take an appropriate learning rate.