Pattern Recognition and Machine Learning : Assignment 2

- The assignment is **due** on **April 10**.
- Submit a soft copy of the code and report highlighting the observations and inferences before the deadline.

In this assignment, I expect you to consider the Karhunen Loeve Transform (Principal Component Analysis) to the problem of Face Reconstruction and Recognition.

Task 1

The gallery folder **'Gallery.zip'** contains images from 40 individuals, each of them providing 5 images. The pixel intensities of the 200 face images will be used for computing the KL Transform. By employing the method of efficient computation of the basis vectors for high dimensional data (discussed in class),

(i) Display the Eigenface images corresponding to the top 5 Eigen values of the covariance matrix $\mathbf{\Sigma}$.

(ii) Plot a graph depicting the percentage of the total variance of the original data retained in the reduced space versus the number of dimensions. From this graph, find the number of dimensions required for projecting the face vectors so that at least 95% of the total variance of the original data is accounted for in the reduced space.

(iii) Reconstruct the image 'face_input_1.pgm' using the: top 15 Eigenfaces

The test image folder **'Probe.zip'** contains 5 images of each of the 40 individuals.

Classify the test samples in this folder by a 3-nearest neighbor classifier (with Euclidean distance) in a reduced 25 dimensional subspace. Compute the classification accuracy.

Task 2

In this task, you will implement a Fisher Linear Discriminant for classifying the face images from the probe folder. You may use the principal components obtained using the 200 Eigenfaces from Task 1 as the features. Project the data on to the 39 significant eigenvectors and report the accuracy using the 3-nearest neighbor classifier for each case.

Task 3

Implement a Gaussian Mixture Model (GMM) based clustering scheme on the image '`ski_image.jpg`'. To aid you through this task, you may consider incorporating the following suggestions :

- Assume that the mixture comprises 3 Gaussian components (clusters).
- The RGB values of pixel intensities (after appropriate normalization to the range [0,1]) can be used as features.
- You may consider starting the iterations using the means

$$\boldsymbol{\mu_1} = \begin{bmatrix} 0.47 \\ 0.47 \\ 0.47 \end{bmatrix} \qquad \boldsymbol{\mu_2} = \begin{bmatrix} 0.05 \\ 0.05 \\ 0.05 \end{bmatrix} \qquad \boldsymbol{\mu_3} = \begin{bmatrix} 0.7 \\ 0.7 \\ 0.7 \end{bmatrix}.$$

- The covariance matrix corresponding to each Gaussian may be initialized as

$$\boldsymbol{\Sigma_i} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \qquad i = 1, 2, 3$$

- The weighting of each Gaussian component (prior weights) in the GMM may be initialized to $\mathbf{\frac{1}{3}}$.

$$\boldsymbol{\pi_i} = \frac{1}{3} \qquad i = 1, 2, 3$$

- It is very important that you iterate through the algorithm several times , so that the likelihood function converges.

(a) Display the segmented output.

(b) Display a graph depicting the convergence of the log likelihood values.

(c) What are the final values of the means, prior weights and covariance matrices