CSE 152 Assignment 4
Spring 2006
Due Friday, June 9, 5:00 PM

Instructions :

- Follow all naming conventions suggested in the questions.
- Please comment all your Matlab code adequately.

1 The Yale Face Database

In this assignment, we will have a look at some simple techniques for object recognition, in particular, we will try to recognize faces. The face data that we will use is derived from the Yale Face Database - to get more information on the database, have a look at the website

`http://cvc.yale.edu/projects/yalefacesB/yalefacesB.html`

where you can also get many more details on the image acquisition process. In short, the entire database consists of 5760 images of 10 individuals, each under 9 poses and 64 different lighting conditions. The availability of such standardized databases is important for scientific research as they provide a common testing ground for the efficacy of different algorithms.

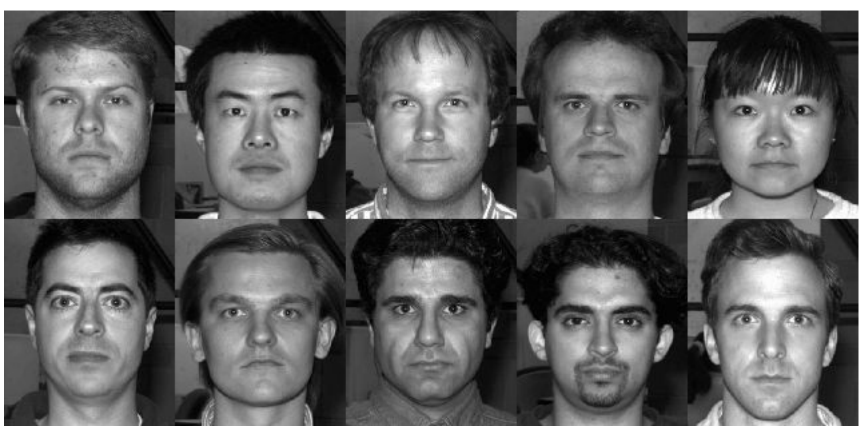

Figure 1: The Yale Face Databse B

For our purposes, we will need only the 640 images that correspond to frontal orientation of the faces. These faces are included in the file `yaleBfaces.zip`. You will find the faces divided into 5 different subsets. Subset 1 consists of images where the light source direction is almost frontal, so that almost all of the face is brightly illuminated. From subset 2 to 5, the light source is progressively moved toward the horizon, so that the effects of shadows increase and not all pixels are illuminated.

The faces in the subset 1 will be used as training images and subsets 2 to 5 will constitute the test set.

2 Recognition Using Eigenfaces

(a) Write a function *eigenTrain*, which takes as input the $50 \times 50 \times 70$ matrix of all the face images from subset 1. Vectorize each face image and store in a matrix, A, which is 2500×70. Perform PCA on the data represented by the matrix A and retain the top 20 eigenbases. **[5 points]**

(b) Rearrange the top 9 eigenbases you obtain in part **(a)** into 2D arrays of size 50×50 and display in a 3×3 format, using the Matlab function *subplot*. **[2 points]**

(c) Write a function called *eigenTest*, which takes as input a 3D array containing all the images from subsets 2 to 5 (the test set) and the eigenbasis set computed in part **(a)**. Project each image of the test set onto the space spanned by the first 10 eigenbases, as discussed in class. Based on the $L2$-distance of this lower dimensional projection from the projections of the training images on the same basis, classify each image of the test set as belonging to one of Persons 1 to 10. The output of *eigenTest* must be a 10×5 matrix R, where R_{ij} is the fraction number of images of Person i that were misclassified when the image was derived from subset j. Also, tabulate your results in a table as shown below: **[5 points]**

Eigenfaces : Error rate with d Principal Components

	Subset 1	Subset 2	Subset 3	Subset 4	Subset 5
Person 1					
Person 2					
Person 3					
Person 4					
Person 5					
Person 6					
Person 7					
Person 8					
Person 9					
Person 10					
Net Error (%)					

(d) Repeat part **(c)**, but now use the first 20 principal components, instead of only the first 10. How do you explain the difference in recognition performance from part **(c)**? **[5 points]**

(e) Again, repeat part **(c)**, but now take the 10 principal components between 4 and 13. How do you explain the difference in recognition performance from part **(c)**? **[5 points]**

(f) Can you explain the error rates you obtain for subset 1 in parts **(c)** to **(e)**? Discuss any trends you observe in the variation of error rates as you move from subsets 2 to 5? **[3 points]**

3 Recognition Using Fisherfaces

(a) Let the number of training images be N (in this case, $N = 70$) and the desired number of bases be $c - 1$. Use PCA to project each training image into a space of dimension $N - c$. Now apply Fisher's Linear Discriminant to obtain a $c - 1$ dimensional feature vector for the face images. Do this for $c = 10$. Your Matlab code must be contained in a function called *fisherTrain* that takes as input the $50 \times 50 \times 70$ matrix of all the face images from subset 1 and the number of bases, c and returns the Fisher bases as output. **[7 points]**

(b) Rearrange the 9 Fisher bases you obtain in part **(a)** into 2D arrays of size 50×50 and display in a 3×3 format, using the Matlab function *subplot*. **[2 points]**

(c) Similar to question **2(c)**, perform recognition on the test set derived from subsets 2 to 5 by projecting onto the space spanned by the basis vectors you computed in part **(a)**. Write a function *fisherTest* that takes as input a $3D$ array of test images as well as the Fisher bases computed in part **(a)** and returns a 10×5 error rate matrix as output corresponding to each person and each subset. Tabulate your results as in questions **1(c) - (e)**. **[9 points]**

4 Comparison

(a) Plot a graph of the net error rates versus subset number computed in questions **2(c) - (e)** and question **3(c)**. Discuss the observed trends in the graph. **[4 points]**

(b) Explain, qualitatively, the reason for the difference in recognition rates achieved by the Eigenface and Fisherface methods for a comparable number of basis images. **[3 points]**