Project 2
CSC 9010 - Computer Vision
Grading: 150 points
Due Date: March. 12, 2015

Description: One of the seminal papers in Computer Vision and face recognition is the idea of Principal Component Analysis and Eigenfaces. In this project, you will be implementing the Eigenface code in Matlab and use eigenfaces to do both face reconstruction and face matching. For the dataset, we will be using the extended yale face database B, see Figure 4. The database can be downloaded here, http://vision.ucsd.edu/extyaleb/CroppedYaleBZip/CroppedYale.zip

Note: Because of the popularity of Eigenfaces, there are quite a large number of resources online that essentially do this project for you. You can consult these resources if you feel it necessary; however, It is expected that the work that you turn in is your own.

Figure 1: CSC 9010 Computer Vision - Images from the extended yale face database B.

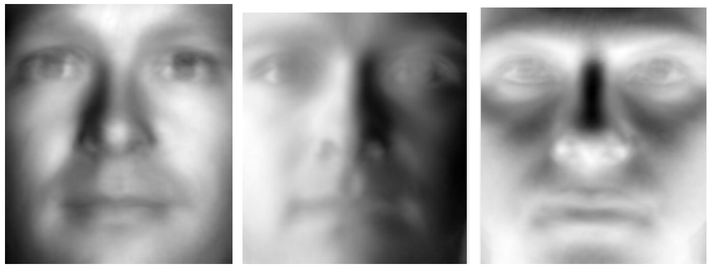
Part 1 - Mean face (30 points)

For the first part of this project, you will download the provided faces and construct a matrix of faces where the columns of the matrix represent a face instance, and the rows of the matrix hold the pixel values of the face. For example, if you are dealing with 20 faces that are 168px x 192px, your face matrix will be 32256 x 20. Using this matrix construct the mean face, or average face, of a subset (at least 100) or all of the faces in your database and display this image.

Figure 2: CSC 9010 Computer Vision - Mean or average face of 954 images.

Part 2 - Eigen decomposition (30 points)

Once you have the mean face, you can proceed to find the covariance of the features (pixels) of the face. Subtract the mean of the face from each instance and store that in a matrix A. The covariance of the faces can then be computed using the formula, $L = AA^T$. However, you will find that performing the eigen decomposition on a matrix that is 32256 x 32256 is an intractable problem. Thus, it is recommended that you perform the eigen decomposition on the matrix, $C = A^T A$ and find the eigenvalues of the L matrix by the formula, $A * eig(C)$.



(a) Eigenvector 1 (b) Eigenvector 2 (c) Eigenvector 3

Figure 3: CSC 9010 Computer Vision - Top 3 eigenfaces.

Part 3 - Face reconstruction (30 points)

Given a new face (can be one you pick or it can be a face randomly selected from your training set), reconstruct the image by finding the coefficients of the image in the eigenvector "face space" by computing the dot product between the basis and the image. You will be choosing the new m basis by computing the ratio m eigenvalues to d dimensions using the formula and computing the m basis that give you 90% of the variance,

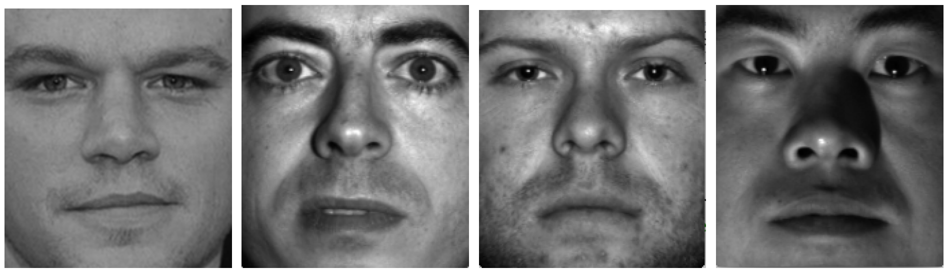
$$\frac{\sum_{i=1}^{m} \lambda_i}{\sum_{i=1}^{d} \lambda_i} > 0.9 \tag{1}$$

Demonstrate the reconstruction of a face by using either 90% of the eigenvectors up to a max of 20. For reference, the dataset that I am using that consists of 954 images, 16 eigenvectors describe 90% of the variance.

(a) Matt Damon (b) 24 face reconstruct

Figure 4: CSC 9010 Computer Vision - Face reconstruction using the basis vectors (24 shown here).

Part 4 - Face matching (30 points) Select 5 arbitrary faces from the internet (or they could be your own) and compute the best match of these faces to the faces in your training dataset. You should normalize your images so that they are the same size as the training images, and are centered around the face, and are in grayscale. First compute the distance using SSD in the pixel space, then in Euclidean Face space, and then compute the distance in Mahalanobis Face space. Present the results in your write up. You should have a total of 5 test images and a total of 15 results. Recall that SSD is the sum of squared differences measure, $SSD = \sum_i^n (I1_i - I2_i)^2$, where n is the total number of pixels in an image and $I1$ and $I2$.



(a) Matt Damon (b) SSD best match (c) Eucledian best match (d) Mahalonobis best match

Figure 5: CSC 9010 Computer Vision - Best matches found in the database.

Part 6 - PDF write up (30 points) Create a 3-5 page write up that summarizes the interesting parts of your program and includes results. Include any problems or insights that you encountered.

Deliverables: Submit on Blackboard.