Question 1

CS663 (Digital Image Processing) Assignment 4

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Question 1

PART

I

Problem 1

In this part, you will implement a mini face recognition system. Download the ORL face database from the homework folder. It contains 40 sub-folders, one for each of the 40 subjects/persons. For each person, there are ten images in the appropriate folder named 1.pgm to 10.pgm. The images are of size 92 by 110 each. Each image is in the pgm format. You can view/read the images in this format, either through MATLAB or through image viewers like IrfanView on Windows, or xv/display/gimp on Unix. Though the face images are in different poses, expressions and facial accessories, they are all roughly aligned (the eyes are in roughly similar locations in all images). For the first part of the assignment, you will work with the images of the first 32 people (numbers from 1 to 32). For each person, you will include the first six images in the training set (that is the first 6 images that appear in a directory listing as produced by the dir function of MATLAB) and the remaining four images in the testing set. You should implement the recognition system by using the eig or eigs function of MATLAB on an appropriate data matrix. Record the recognition rate using squared difference between the eigencoefficients while testing on all the images in the test set, for $k \in \{1, 2, 3, 5, 10, 15, 20, 30, 50, 75, 100, 150, 170\}$. Plot the rates in your report in the form of a graph. Now modify the required few lines of the code but using the svd function of MATLAB (on the $\boldsymbol{L}$ matrix as defined in class) instead of eig or eigs.

Repeat the same experiment (using just the eig or eigs routine) on the Yale Face database from the homework folder. This database contains about 64 images each of 38 individuals (*labeled from 1 to 39, with number 14 missing; some folders have slightly less than 64 images*). Each image is in pgm format and has size 192 by 168. The images are taken under different lighting conditions but in the same pose. Take the first 40 images of every person for training and test on the remaining 24 images (that is the first 40 images that appear in a directory listing as produced by the dir function of MATLAB). Plot in your report the recognition rates for $k \in \{1, 2, 3, 5, 10, 15, 20, 30, 50, 60, 65, 75, 100, 200, 300, 500, 1000\}$ based on (a) the squared difference between all the eigencoefficients and (b) the squared difference between all *except* the three eigencoefficients corresponding to the eigenvectors with the three largest eigenvalues. Display in your report the reconstruction of any one face image from the ORL database using $k \in \{2, 10, 20, 50, 75, 100, 125, 150, 175\}$ values. Plot the 25 eigenvectors (eigenfaces) corresponding to the 25 largest eigenvalues using the subplot or subimage commands in MATLAB. [35 points]

Section 1

ORL Dataset

Subsection 1.1

Using `eig` or `eigs`

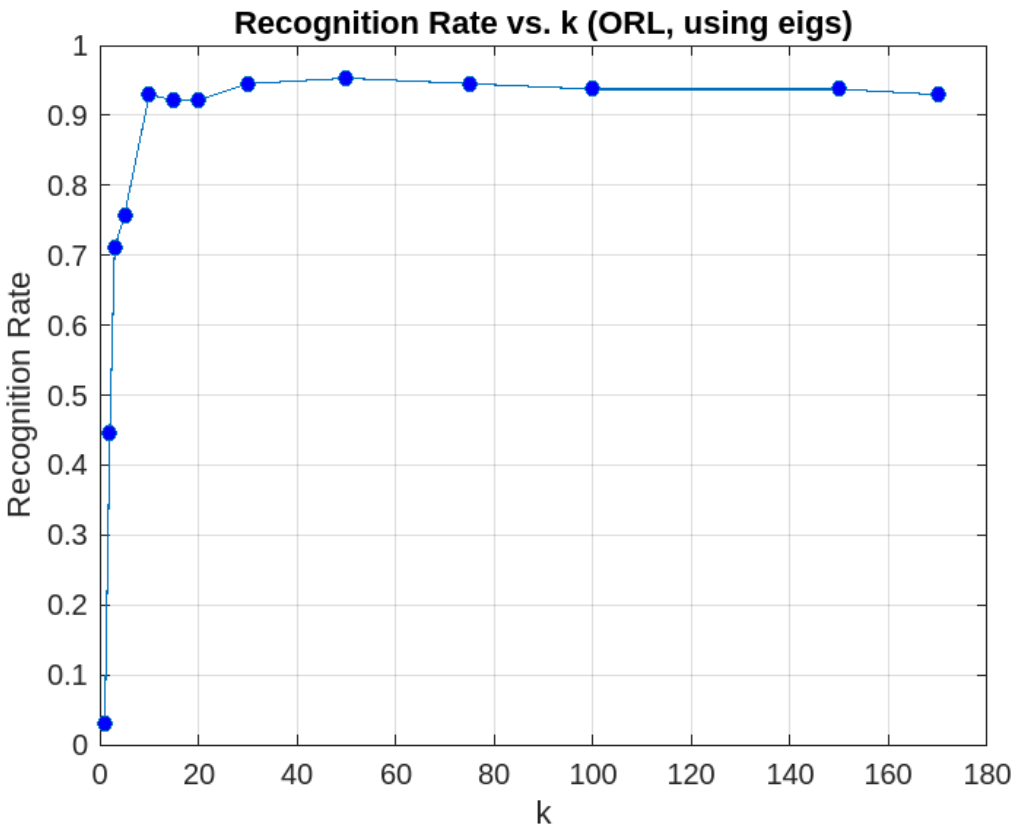

Figure 1. Recognition Rate vs k for ORL dataset, using `eigs`

The above plot shows the recognition rates vs k for ORL dataset, when we used `eigs` function of MATLAB. As seen from the plot, the recognition rate is found to be maximum at $k = 50$ with value of 0.9531

Subsection 1.2

Using `svd`

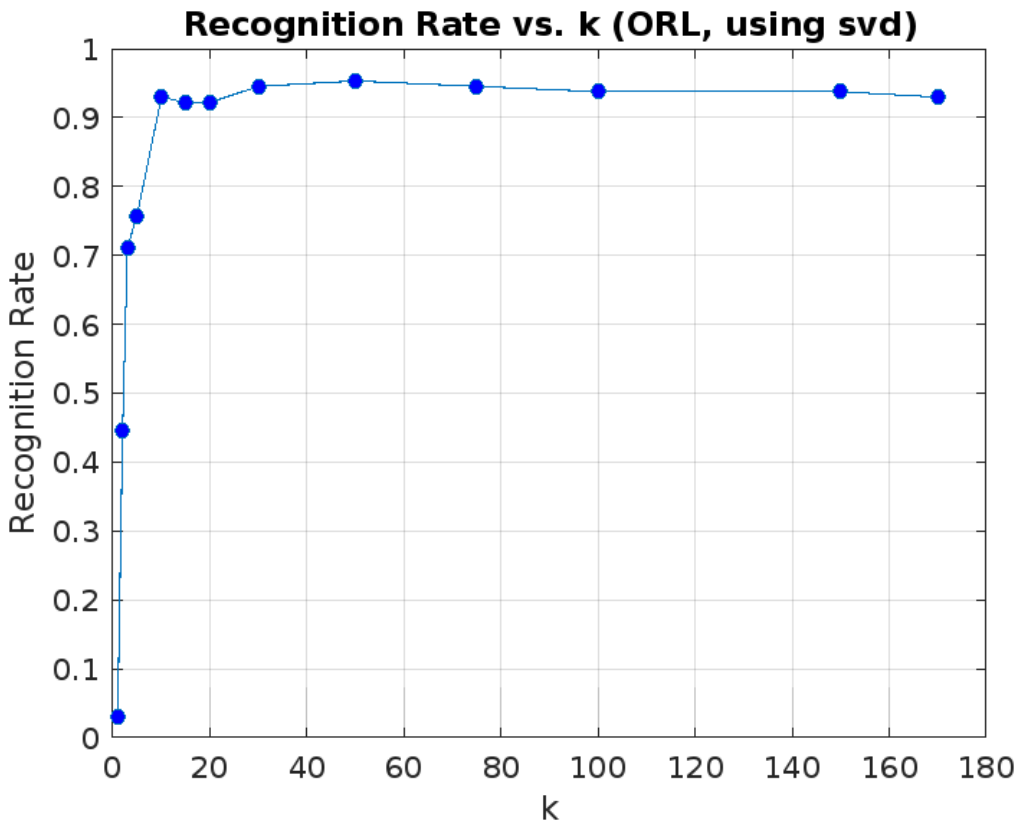

Figure 2. Recognition Rate vs k for ORL dataset, using `svd`

The above plot shows the recognition rates vs k for ORL dataset, when we used `svd` function of MATLAB. As expected, same rates were seen in this case, as seen before with `eigs` function, with, maximum rate = 0.9531 at k = 50.
Note that you would have to comment down the lines for eigs function and uncomment the lines for svd function in our code to run it using svd.

Section 2

Cropped Yale Dataset

Subsection 2.1

Squared distance between all Eigen-coefficients

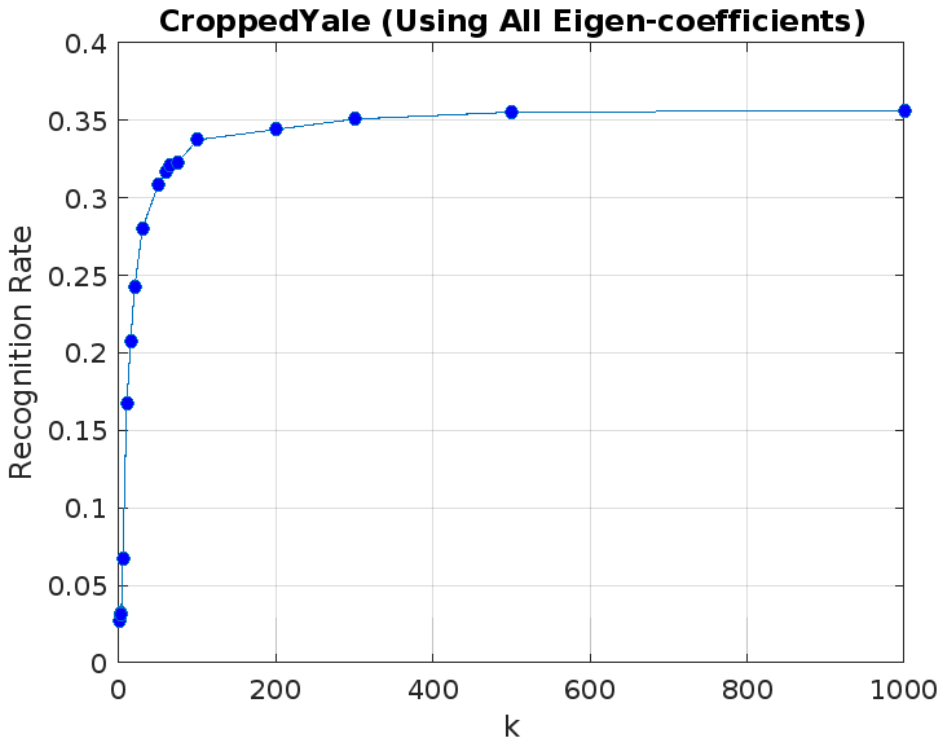

Figure 3. Recognition Rate vs k for CroppedYale, using all the eigen-coefficients

When we use all the eigen-coefficients for finding the squared distances, the maximum recognition rate achieved is around 0.35
Note that since Yale is a larger dataset, it takes around 240 seconds just to read the dataset. So running the code will take this much time.
However, if you want to run the code again for (b) part of except top 3, you can uncomment the lines which save the data in a file `yale_data.mat`*, and then load that file when training and plotting the rates again for the (b) part*

Subsection 2.2

Squared distance between all, except Top 3

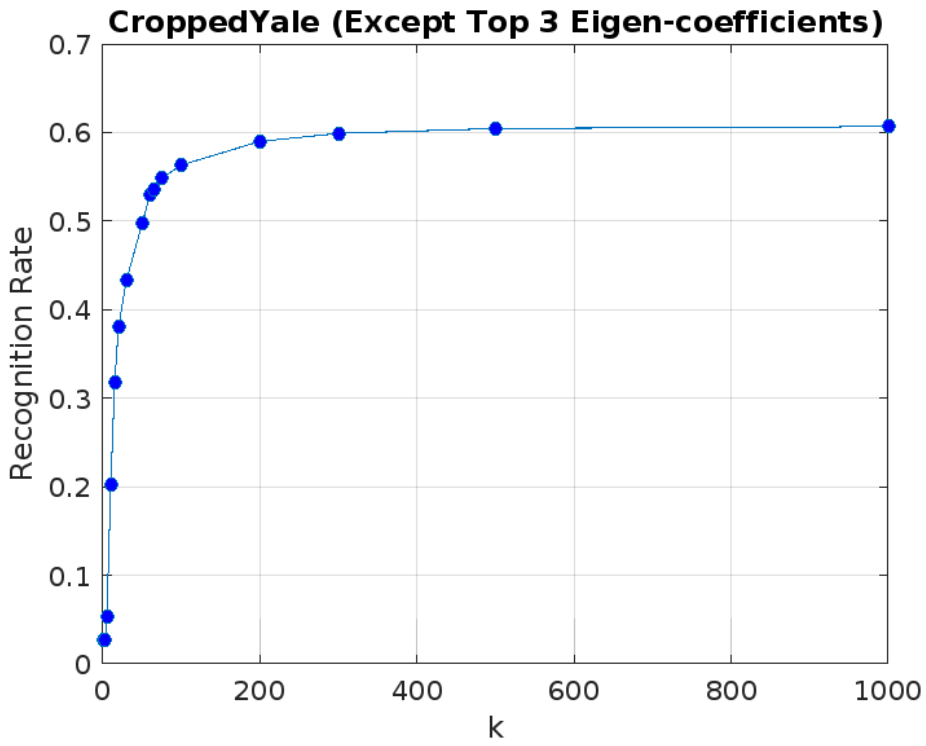

Figure 4. Recognition Rate vs k for CroppedYale, using all eigen-coefficients except the top 3

But, when we use all eigen-coefficients except the **top 3**, for finding the squared distances, the maximum recognition rate achieved is around 0.6, which is much better. This verifies from the result that we studied in class, that when lighting is varied, then removing the top 3 principal components produces better results

Note that you would have to comment/uncomment some lines in our code to run for except top 3 case. We have instructed which lines to comment/uncomment as comments in our code.

Section 3

Face Reconstruction (from ORL)

Figure 5. Original Image at `s14/5.pgm`

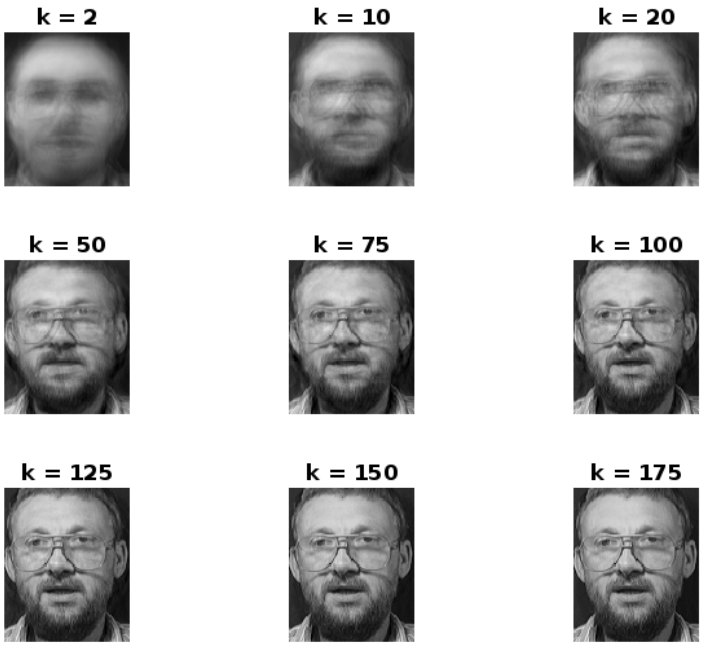

Figure 6. Reconstructed the above image at different values of k

We observe that the reconstruction gets better as k increases

Section 4

Top 25 Eigenfaces

Subsection 4.1

ORL Dataset

Figure 7. Top 25 Eigenfaces of ORL dataset

Note that the eigenfaces are plotted from top left to bottom right order. That is, the eigen face with largest eigenvalue is at top left corner, then they go towards right. The eigenface with top 25th eigenvalue is at bottom right corner.

Subsection 4.2

Cropped Yale Dataset

Figure 8. Top 25 Eigenfaces of Cropped Yale dataset