Syracuse University
Department of Electrical Engineering and Computer Science

CSE 400/691 Image and Video Processing
Spring 2020

Assignment V

1) Eigenfaces (75%)

Implement a face recognition system using the Eigenfaces described by Turk and Pentland. First, randomly separate the faces in the database into training and test data. You should:

a) [5%] Read images from the training set, and collect them in one matrix (**Hint:** Each image should be one column of this matrix). Then, find the average face of the training set, and display it (**Hint:** Help `reshape`).

b) Perform PCA in the following ways:

i) [5%] Find the eigenvectors of the $\mathbf{X}\mathbf{X}^T$, where $\mathbf{X}$ is the data set matrix.

ii) [5%] Use SVD (**Hint:** Please refer to the slides).

iii) [5%] Find the eigenvectors of $\mathbf{X}^T\mathbf{X}$, then use the method described in the paper titled "Eigenfaces for Recognition" by Turk and Pentland.

c) [10%] Compare the principal components from parts b.i, b.ii and b.iii. Measure the number of seconds required for each of the three methods in part (b) above (**Hint:** help `tic`, help `toc`).

d) [10%] Find the n significant eigenvectors with the largest associated eigenvalues. (Please refer to part 2(a) to experiment with different values of n.)

e) [15%] Read images from your test set. For each image, subtract off the average image obtained in part 1(a), and project it onto the basis spanned by the top n eigenfaces. (This will give you the weights.)

f) [10%] Reconstruct the test images by using the weights from part 1(e) and the n eigenfaces. Show the original and reconstructed images for 10 of your test images (**Hint:** Do not forget to add the average image at the end).

g) [10%] Pick 20 images from your test set, and find the closest image in the training data set to each of these 20 images. Show 10 of the matches as examples (**Hint:** you will use the weight vectors).

2) Questions, evaluation and comments (25%)

a) [5%] How many eigenfaces are necessary to obtain recognizable reconstructions? i.e. how big does n have to be before the reconstructed images look recognizable?

b) [5%] Calculate the recognition rate from part 1(g) above.

c) [5%] What happens when you do not include the images with glasses in your experiments? How does the recognition rate change? Why?

d) [5%] Project the provided non-face images onto the space spanned by the n eigenfaces. Find the difference between each image and its reconstructed version. Show the original images, reconstructed images and the difference images. Find the Frobenius norm of each difference image, and plot these values. (You will need to resize these images to match their sizes to the database images.)

e) [5%] Repeat part 2(d) for 10 of the face images from the test set. (Note: You already have the reconstructed versions of the test images from part 1(f) above. Thus, you will only need to find the difference images, find the Frobenius norm of each difference image, and plot these values for the face images from your test set.) Comment on the results of parts 2(d) and 2(e).