ECE 442 H51 LAB 3

KNN and Face recognition

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Question 1: Plot eigenvalues vs index. Look at the decay of the eigenvalues. How would you choose K?

Solution: The plot image is given below, as we can see from the plot that the value (important details of an image) of eigenvalues dramatically decreases as we go through more and more eigenfaces, but a saturation point is reached at about 25-100 mark, not improving much of image detail through additional values, while increasing computational load. Thereby we choose K as something in between of the above range, K = 50 is chosen for this lab.

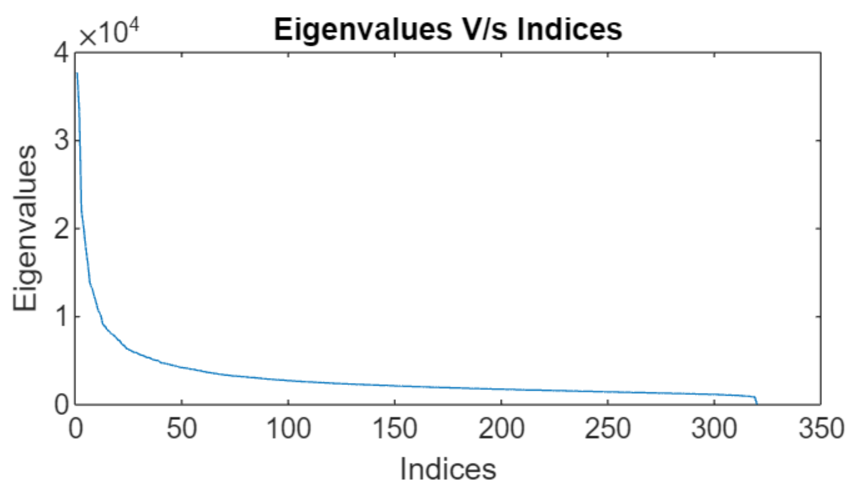

Figure 1: Plot of eigenvalues v/s indices

Question 2: Calculate the Euclidean distance between $\boldsymbol{W}arctichare$, $\boldsymbol{Wmean}$ ($\boldsymbol{d}arctichare$). Now pick an image from the faces database test folder. Find eigenfaces weights again using Eq.1 and form the matrix of weights ($\boldsymbol{Wtest}$). Calculate the Euclidean distance between $\boldsymbol{Wtest}$, $\boldsymbol{Wmean}$ ($\boldsymbol{dtest}$). Compare $\boldsymbol{d}arctichare$, $\boldsymbol{dtest}$. What do you observe?

Solution: d_arctichare = 9841.4, d_test = 3462.1, Since the arctichare image is a completely different kind of image as compared to a Face image with almost no matching features at all, therefore its Euclidean distance(difference between weight contribution of the eigenfaces) is greater as compared to a Euclidean distance of the test image which is a Facial image.

```
d_arctichare = 9.8414e+03
```

```
d_test = 3.4621e+03
```

Figure 2:

Question 3: Find the matrix of weights for 4 other test samples and find the Euclidean distance between the matrices and $\boldsymbol{Wmean}$. Pick a reasonable threshold to be able to distinguish face images from other images?

Solution: The values for the Euclidean distances for the test images are given below in the Figure 3. We can select a threshold of around 5500 which, we can safely assume will be classified as a facial image.

```
d_test_four = 1×4
10^3 ×
    3.2011    4.2917    5.3056    3.8737
```

Figure 3: Euclidean distance test values all under 5500

Question 4: Construct the faces with the eigenface contribution weight matrix of ($\boldsymbol{Wp{-}mean1}$,$\boldsymbol{Wp{-}mean2}$, … ,$\boldsymbol{Wp{-}mean5}$) and plot them. Do they look like the first 5 subjects face images? What attributes do the resulted images have in common with the original images of subjects (hair style, rotation of head, illumination, …)

Solution: Done on the MATLAB Code Line 106 – 131 of the .mlx file, couldn't do separate files this time because of the dependency of the Initial Training Data throughout the Code. Plotted images are attached along zip file and shown below in Figure 4 compared to their original images in the training data set, we can see that the colour contrast of the image, rough indication of facial features like beard, mouth, eyes, nose position, gender difference between images male or female is common with the original images of subjects.

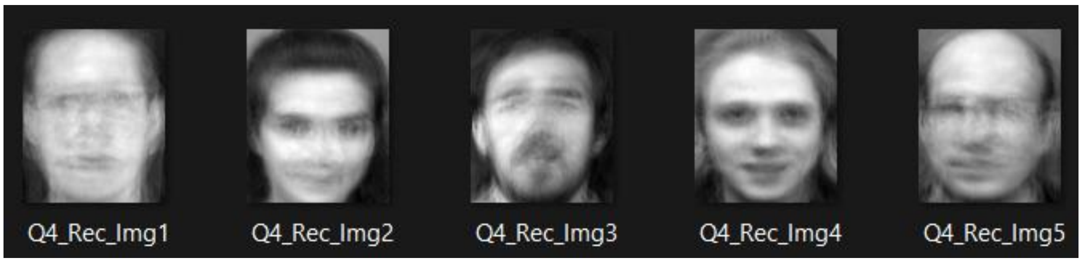

Figure 4 : Faces with W_p_mean eigenface contribution

Question 5: Calculate Euclidean distance of the first test sample weight matrix with each of $\boldsymbol{Wp{-}mean1}$, $\boldsymbol{Wp{-}mean2}$, $\boldsymbol{Wp{-}mean3}$, … ,$\boldsymbol{Wp{-}mean40}$. Report the $\boldsymbol{Wp{-}mean}$ with the shortest distance and declare its index as the label of the first test sample. Do the same thing for the other test images. Report the accuracy of prediction over these 80 tests images.

Solution: Done on the MATLAB Code Line 151 – 184, The shortest distance W-p-mean and the accuracy of the prediction over 80 images is given below alongside with the computation runtime for this model in the figure 5.

```
W_p_mean_shortest_1st_sample = 3.2904e+03
Accuracy = 0.8875
Elapsed time is 0.023227 seconds.
```

Figure 5: Shortest distance, accuracy, and runtime.

Question 6: Find the K shortest distances (Assume that K=5) and report the mod of the K samples labels as the predicted label of the first test image. Do the same thing for other 79 test images. Report the accuracy of prediction over these 80 test images. Compare the accuracy with accuracy of Question5. Which one of these methods do you prefer for classifying a new image (in terms of accuracy, runtime, …)? Why? (You may use the tic and toc commands of MATLAB to compare the calculation complexity of the methods)

Solution: Done on the MATLAB code Line 186 – 214. The K shortest distance, predicted label for the first test image and accuracy of the predictions is given below in the figure 6, We can use either (Q5 or Q6 model) of them as the first one has a shorter runtime(0.047 s < 0.1 s), whereas second has better accuracy(88.75 % < 90 %), for our classification and prediction purposes the accuracy matters more as runtime is too short to be regarded as a bottleneck for our specific program. Hence, we will prefer 2^{nd} model (Q6).

```
W_p_mean_shortest_1st_sample = 3.2904e+03
Accuracy = 0.8875
Elapsed time is 0.046994 seconds.
pred_label_1st_test_image = 1
Accuracy_K = 0.9000
Elapsed time is 0.107207 seconds.
```

Figure 6: Required parameters.

Question 7: Calculate eigenfaces weights matrix for your photo and compare it with $\boldsymbol{W}arctichare$(arctic hare image weight matrix) and $\boldsymbol{Wmean}$(training set weight matrix) that you had calculated before. What do you see? Treat your photo as a test image and test it on the implemented KNN algorithm. What similarities do you see between your photo and the predicted class image (Age, gender, glasses, …)?

Solution: The calculated eigenfaces matrix are shown below in the figure 7, value of mean weight contribution eigenfaces is low compared to other two images.
My photo, see figure 8, when treated as test image is the classified by the algorithm as s37 in training dataset. We can see that photos have certain similarities like the gender, glasses, facial expression, head orientation and the beard.

```
W_gvs = 50×1
10^3 ×
     -1.5555
     -0.4149
     -0.2057
     -2.0599
      1.1866
     -0.2735
     -1.1374
     -0.6331
     -0.1685
     -0.2725
        ⋮

W_arctichare = 50×1
10^3 ×
      7.0912
      1.0925
      0.1702
     -0.4861
     -4.8493
      1.8142
     -0.8567
      1.8879
      1.6465
      0.0911
        ⋮

W_mean = 50×1
10^-13 ×
      0.2558
     -0.1421
           0
     -0.0568
      0.0924
      0.3588
     -0.1101
     -0.1137
      0.0853
     -0.0995
        ⋮

pred_label_gvs = 31
```

Figure 7,8: Weight eigenfaces contribution for arctichare, mean and our own image.

 is classified by KNN algorithm as