Matrix Theory HW-2: Face classification using PCA and k-NN

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1 Dataset description.

The training set contains 40 persons(i.e. classes) and 10 images per person. From each class 80% of the images are chosen at random and added to the training set and the rest 20% is added to the test set. Eigen faces are learnt using the training set. The eigen faces are learnt in the following way. Consider the data matrix X in the form: each row is an image vector.

$$Covariance\,matrix(C) = \sum_i (X_i - \mu)^T (X_i - \mu)\,(where,\ \mu\, is\, feature\, wise\, mean\, vector) \tag{1}$$

$$U, S, V = SVD(C), \tag{2}$$

where S in the matrix of eigen vectors and S is a diagonal matrix with eigen values in decreasing order as diagonal elements.

To project the image vector in lower dimension perform the following operation:

$$X_{red} = U[1:k]^T X', \tag{3}$$

where, k is number of principle components to choose. and X' $(X - \mu)$ is the mean subtracted image vector. To reconstruct the image perform the following operation:

$$X_{recons} = U[1:k] X_{red}, \tag{4}$$

where, X_{recons} is reconstructed image with k principle values.

2 PCA reconstruction demonstration on the training set.

Fig. 1 and Fig. 2 shows the original image and reconstructed image with #k equals to 50 and 100. These images are taken from the training set. As the value of k increases the quality of reconstruction improves.

Figure 1: The image on the left is the original image and the image on the right in the reconstructed image with #k=50. The reconstruced image have started to look like the original image.

Figure 2: The image on the left is the original image and the image on the right in the reconstructed image with #k=100. As #k is increased the reconstruction quality improves.

Figure 3: The first image at the top left is the mean test image, second image in the original images. The rest of the images are reconstructed images with #k=30,50,70,100,140,300,500,800,4000 in order.

3 PCA reconstruction demonstration on the test set.

Fig. 3 shows the original image, mean image and reconstructed images at different values of k. At $k = 30$ the reconstructed image resembles the mean image, but as k increases the quality of reconstruction improves. After a certain value of k the improvement is very subtle. The reconstruction at $k = 4000$ is of fairly good quality. It has started to capture the facial expressions of the person. At lower values of k the expressions are not that prominent. As eyes seems to emerge at higher values of k.

4 Face classification results

The Table 1 shows the face classification results with K-NN classifier with number of neighbors equal to 5. It gives an accuracy of 92.1% at $k = 40$. But the accuracy doesn't improve as we increase the value of k. It seems the prominent facial features are captured first and then the subtle facial features are captured at higher principle components. It makes sense because prominent components will have higher eigen values and therefore these are important for face

Number of Principle Components	Accuracy
30	89.47
40	92.1
50	90.78
60	92.1
70	92.1
80	92.1
90	92.1
1000	92.1

Table 1: k-NN classification results with number of neighbors=5

classification. Hence face classification is good at lower value of k. In this case $k = 40$ is good.