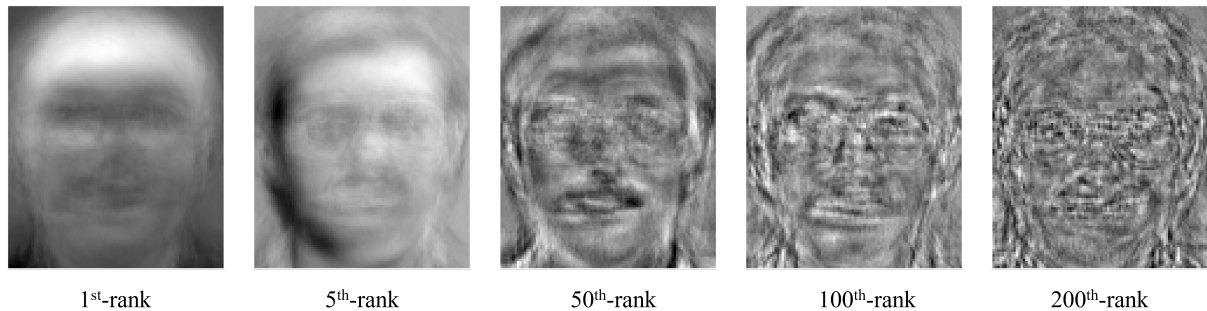


Eigenface Extraction

Q1: How do the (leading) eigenfaces look like as an image? How does the importance of the eigenfaces decrease?

The leading eigenfaces look like human faces in this dataset. As the ranking of the eigenfaces decrease, they contribute less to human-face features.

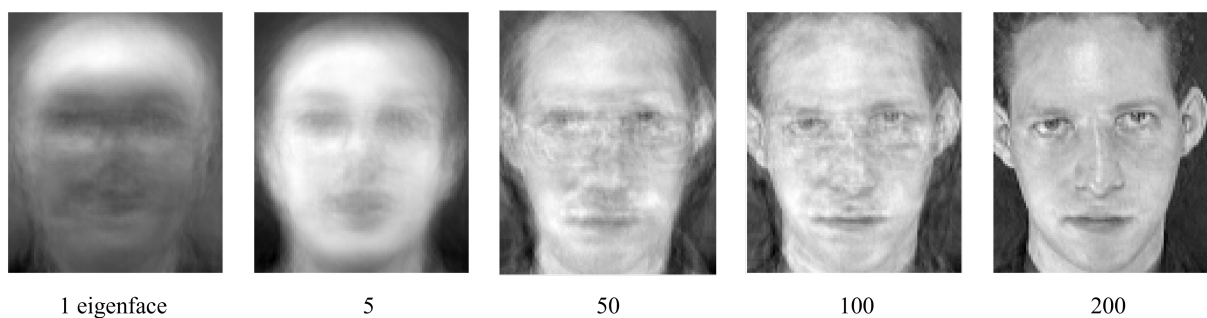
We show several examples of the eigenfaces:



Face Reconstruction with PCA

Eigenfaces can be used to compress the original face image. As the number of eigenfaces used increasing, the reconstruction quality gets better.

We show the results of using the first n eigenfaces to reconstruct the first image (/s1/1.pgm):



Q2: How many eigenfaces are required to recover an original face with reasonable errors?

This dataset requires about at least 200 eigenfaces. We calculated the L_2 distance between the first reconstructed face image and its original, the results are shown bellow.



We can see that when using more than 250 eigenfaces, the L_2 distance is almost zero.

Face Classification

We use eigenfaces to perform the face classification task. The key idea is that we assume human-face image can be represented by a linear combination of the eigenfaces. Then each class can be linearly represented by the eigenfaces. The coefficient matrix W can be obtained by solving the linear system.

The diagram shows a face image on the left, followed by an equals sign, then a series of terms: w_1 multiplied by eigenface u_1 , plus w_2 multiplied by eigenface u_2 , plus w_3 multiplied by eigenface u_3 , and finally plus an ellipsis (\dots). Below each image is a label: 'Face class (One-hot label)' for the first image, 'Eigenface u_1 ' for the second, ' u_2 ' for the third, and ' u_3 ' for the fourth.

For this task, we use 200 eigenfaces, so W is a 35×200 matrix. Applying W to a transformed test image will produce the scores for the 35 classes. The maxima's according class is the predicted class.

The test accuracy on the 35 classes (70 images) is 98%, which means it can correctly classify the faces.

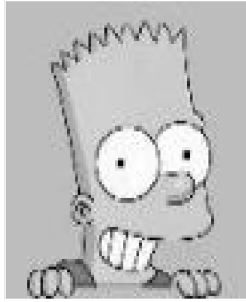
Face Recognition

To recognize an image is whether human face or not, we observe the classification scores of it using the trained model in the above task. If the maximum score of an input image is below a threshold, we think it a non-face image.

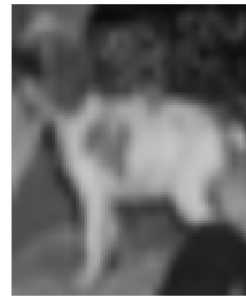
The average score of the testing image (total 120) in this task is 0.5317. So we choose heuristically choose 0.5 as the threshold.



Class 1
0.5215



Class 5
0.5215



Class 5
0.3676

In practice, this method performs not good. The above figure shows examples. For the middle Butt face, it gives almost the same score as att-face. Other images we do not include here even have much higher scores.

Classification with CNN