Mini Project: Face Recognition using Eigen Faces

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***Abstract*— The facial recognition problem can be approached as a 2-D recognition problem. The approach involves using Principal Component Analysis, in which the face images are projected onto a feature space that covers the significant variations among known face images. The significant features (eigenfaces) are the principal components of the sets of faces. Since projection operation characterized an individual face by a weighted sum of the eigenface features, so to recognize a particular face it is necessary only to compare these weights to those of known individuals for identification.**

Keywords—eigenfaces; recognition; features; eigenvectors; Principal Component Analysis

GOAL

The goal of this mini project is to get familiarized with the ideas of Principal Component Analysis by applying it for facial recognition of images and to understand the practical difficulties in developing real-world systems that work with acceptable accuracies.

INTRODUCTION

Bio metric recognition, including face recognition, can be carried out in two modes: a) Identification, and b) Verification. In both cases, a few training samples from each class (each person) is collected and stored in a reference database during training. This process is called enrollment. During testing, a test sample is presented, which should be compared against the enrolled samples to decide if they match or not. The matching process differs in the two modes described above. In the identification mode, the test sample is compared against training samples of each of the enrolled persons, and the best match is identified to decide the identity of the person providing the test sample. This is a one-to-many matching process. In the verification mode, the test sample is presented along with a claim of identity. The test sample is matched only against enrollment samples of the claimed identity to decide whether it is a match or not. The process hence verifies whether the identity claim is correct or not. This can be thought of as a one-to-one matching, even though one might compare the test sample against multiple enrollment samples of the claimed person. We find a linear projection of the faces from the high-dimensional image space to a significantly lower dimensional feature space which is insensitive both to variation in lighting direction and facial expression. We choose projection directions that are nearly orthogonal to the within-class scatter, projecting away variations in lighting and facial expression while maintaining discriminability.

Basic steps Performed

- Four fold training and testing for parts a) and b) is done. In this 75% images were taken as training and 25% images were taken for testing.
- For this training is done first for images, in which a matrix 'A' containing feature vectors of each image is stored after resizing the image.
- Then the mean of all images is subtracted from the matrix A.
- Then the Eigen vectors corresponding to 'At*A' (At is transpose of A) are found and sorted according to Eigen values.
- Then the top 25 Eigen vectors are taken, leaving the first 4-5 Eigen vectors in order to increase accuracy.
- Eigenfaces are calculated and normalized.
- Finally Feature vector for each image is calculated and stored.
- Similarly Feature vector for each test images is found.
- Then using 1-NN (nearest neighbor), the nearest matching label is found and reported as result.
- For the verification process the thresh hold value for each class is calculated and if the norm of the test image is less than the thresh hold value of the proposed label then the image is correctly labeled.

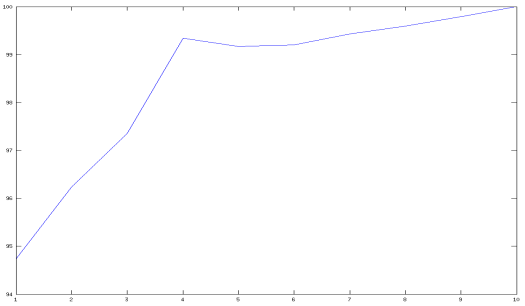
Experiments Performed

In the subsections below, the details of the various experiments conducted and the corresponding results obtained are presented. These results are then supported by some graphs for better comparisons and understanding.

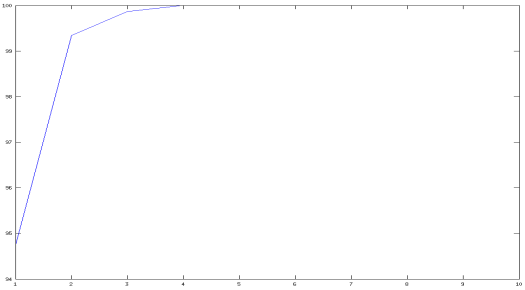
1. Yale Dataset: Eigen Faces + K-NN/Euclidean Distance

In the first experiment, the Yale face dataset that contain face images that are captured under controlled conditions

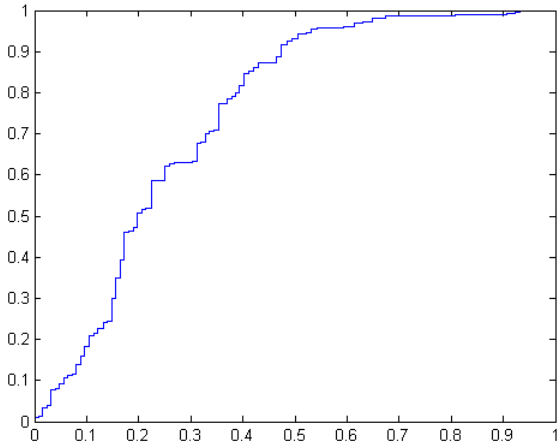
(illumination, pose and expression) and cropped to contain the face only was used. The dataset was divided into four parts and a 4-fold cross validation was performed and accuracies were recorded. The training set was then used to develop the Eigen faces and represent each of the training images as a linear combination of the Eigen face basis. Each of the test samples is then represented in the same Eigen basis, and compared against the training samples using Euclidean distance metric. After this the test image is labeled using 1-NN (nearest neighbor). Also the test images were verified for the correctness of their labels by finding the thresh-hold value for each class using the ROC curve for the class.



Plot of the Verification



Plot of the Accuracies

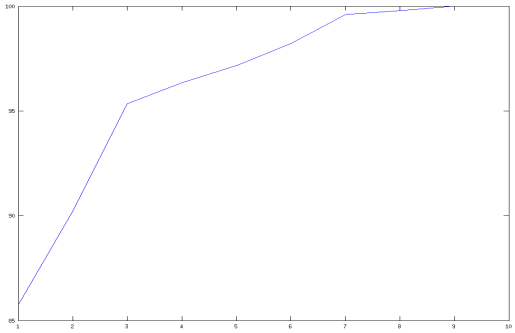


x axis – False Positive
y axis – True Positive

ROC plot for Label 39 for No. of Eigen values 3

2. CMU-PIE Dataset: Eigen Faces + K-NN/Euclidean Distance

The above experiment is repeated for the CMU-PIE dataset which is similar to the Yale Dataset.



Plot of the Accuracies

3. Using an SVM Classifier for Face Recognition

The SVM (Support Vector Machine) classifier constructs a hyperplane or set of hyperplanes in a high- or infinite-dimensional space, which can be used for classification, regression, or other tasks. Intuitively, a good separation is achieved by the hyperplane that has the largest distance to the nearest training data point of any class (so-called functional margin), since in general the larger the margin the lower the generalization error of the classifier.

The svm accuracies were observed to be 100% for input and test images constructed using 25 Eigen vectors.

4. Representation of Unknown faces and Non-faces

A variety of images (both faces and non-faces) of the same size were considered and were represented using the Eigen Face basis. Then these images were reconstructed from the representation.

Observations :-

a) Image from given dataset :- The reconstructed image was very similar to the original image.
b) My Image :- A very absurd image was reproduced.
c) Image of Flower :- Image resembling a face was reproduced.

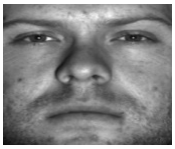



Image Comparison for Part a)


Image Comparison for Part b)


Image Comparison for Part c)

5. Classroom Attendance

The experiment no. 1 was repeated on the Dataset of SMAI students and the accuracy observed is below for four fold testing:-
a) 36.3498%
b) 37.3583%
c) 42.3485%
d) 33.2349%

And 35% for hold-one-out method.

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