A New Optimized Approach to Face Recognition Using EigenFaces

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Sheifali Gupta [1], O.P.Sahoo [2], Ajay Goel[3], Rupesh Gupta[4]
[1] Department of Electronics & Communication Engineering, Singhania University, Rajasthan,India
[2] Department of Electronics & Communication Engineering, N.I.T. Kurukshetra, India
[3] Department of Computer Science & Engineering, Singhania University, Rajasthan, India
[4] Department of Mechanical Engineering, Singhania University, Rajasthan, India
sheifali@yahoo.com , opsahu_reck@yahoo.co.in , goelajay1@gmail.com, rup_esh100@yahoo.co.in

Abstract- **Eigenface approach is one of the simplest and most efficient methods for face recognition. In eigenface approach chosing the threshold, value is a very important factor for performance of face recognition. In addition, the dimensional reduction of face space depends upon number of eigenfaces taken. In this paper, an optimized solution for face recognition is given by taking the optimized value of threshold value and number of eigenfaces. The experimental results show that if the threshold value is 0.8 times of maximum value of minimum Euclidian distances of each image from other images, then maximum recognition rate is achieved. Also only 15% of Eigenfaces with the largest eigen values are sufficient for the recognition of a person. Best optimized solution for face recognition is provided when both the factors are combined i.e. 15% of eigenfaces with largest eigen values are selected and threshold value is chosen 0.8 times maximum of minimum Euclidean distances of each image from all other images, it will greatly improve the recognition performance of a human face up to 97%.**

Keywords-: Eigenface, Face recognition, Euclidean distance.

I INTRODUCTION

The face is our primary focus of attention in social intercourse, playing a major role in conveying identity and emotion [1]. Hence Face recognition has become an important issue in many applications such as security systems, credit card verification and criminal identification [2]. Face Recognition is an emerging field of research with many challenges such as large set of images, improper illuminating conditions [3].

Much of the work in face recognition by computers has focused on detecting individual features such as the eyes, nose, mouth and head outline, and defining a face model by the position, size, and relationships among these features. Such approaches have proven to depend on the precise features [6].

Eigenface approach is one of the simplest and most efficient methods in developing a system for Face Recognition. In eigenface approach, after the dimensional reduction of the face space, the distance is measured between two images for recognition. If the distance is less than some threshold value, then it is considered as a known face, else it is an unknown face [4].

The approach transforms face images into a small set of characteristic feature images, called “eigenfaces”, which are the principal components of initial training set of face images. Recognition is performed by projecting a new image into the subspace spanned by the eigenfaces and then classifying face by comparing its position in face space with the position of known individuals [4].

In this paper, section 2 gives the basic idea of Eigenface approach for human face recognition. Section 3 has brief description of steps involved in Eigenface algorithm. Section 4 deals with the threshold concept used in Eigenface approach Section 5 gives the experimental readings & results. Finally, section 6 gives the conclusion drawn from the research

II EIGENFACE APPROACH

Eigenspace-based approaches approximate the face vectors (face images) with lower dimensional feature vectors [8]. The main supposition behind this procedure is that the face space (given by the feature vectors) has a lower dimension than the image space (given by the number of pixels in the image), and that the recognition of the faces can be performed in this reduced space. This approach considers training, where the face database is created, and the projection matrix, the one that achieve the dimensional reduction, is obtained from all the database face images. Also mean face is calculated and the reduced representation of each database image with respect to mean face is calculated. These representations are the ones to be used in the recognition process [5]. An example of Eigenspace face recognition system is as given below. The basic steps involved in Face Recognition using Eigenfaces Approach [4] are as follows:

A. Initialization

i. Acquire initial set of face images known as Training Set.
ii. Calculate eigenfaces from training set keeping only M images that correspond to highest eigenvalues. These M images define the face-space.
iii. Calculate distribution in this M-dimensional space for each known person by projecting his or her face images onto this face-space.

B. Recognizing New Face Images

i. For given input image, calculate a set of weights based on M eigenfaces by projecting this new image onto each of eigenfaces.
ii. Determine whether the image is known face or not by checking whether its Euclidean distance with other images is less than some threshold value or not.

III EIGENFACE ALGORITHM

Step 1: Prepare the data
In this step, the faces constituting the training set (Γi) should be prepared for processing.
Step 2: Subtract the mean
The average matrix (Ψ) has to be calculated, then subtracted from the original faces (Γ_i) and the result stored in the variable Φ_i

$$\psi = \frac{1}{M}\sum_{n-1}^{M}\Gamma_n$$

$$\phi_i = \Gamma_i - \psi \quad (1)$$

Step 3: Calculate the covariance matrix
In the next step the covariance matrix C is calculated according to

$$C = \frac{1}{M}\sum_{n-1}^{M}\phi_n\phi_n^T \quad (2)$$

Now the eigenvectors (eigenfaces) u_i and the corresponding eigenvalues λ_i of vector C should be calculated.

Step 4: Calculate the eigenvectors and eigenvalues of the covariance matrix
The covariance matrix C in step 3 (see equation 2) has a dimensionality of $N^2 \times N^2$, so one would have N^2 eigenfaces and eigenvalues. For a 256 × 256 image that means that one must compute a 65, 536 × 65, 536 matrix and calculate 65, 536 eigenfaces. Computationally, this is not very efficient as most of those eigenfaces are not useful for our task. In general, PCA is used to describe a large dimensional space with a relative small set of vectors [4]. PCA tells us that since we have only M images, we have only M non-trivial eigenvectors. We can solve for these eigenvectors by taking the eigenvectors of a new M x M matrix:

$$L = A^T A$$

Because of the following math trick:

$$A^T A v_i = \mu_i v_i$$
$$A A^T A v_i = \mu_i A v_i$$

Where v_i is an eigenvector of L. From this simple proof we can see that Avi is an eigenvector of C. The M eigenvectors of L are finally used to form the M eigenvectors u_l of C that form our eigenface basis:

$$u_l = \sum_{k=1}^{M} v_{lk}\phi_k$$

Where u are the eigenfaces. Usually, we will use only a subset of M eigenfaces, the M' eigenfaces with the largest eigenvalues. Eigenfaces with low eigenvalues can be omitted, as they explain only a small part of characteristic features of the faces.

Step 5: Recognizing the faces
The process of recognizing of a new (unknown) face Γ_{new} to one of the known faces proceeds in two steps. First, the new image is transformed into its eigenface components. The resulting weights form the weight vector Ω^T

$$W_k = \mu_k(\Gamma_{new} - \Psi)$$

$$\Omega^T = [w_1 w_2 ....w_{M'}$$

The Euclidean distance between two weight vectors d(i,j) provides a measure of similarity between the corresponding images i and j. If the minimum Euclidean distance between Γ_{new} and other faces exceeds - on average - some threshold value θ, one can assume that Γ_{new} is an unknown face, Else it is considered as a known face.

IV THRESHOLD DECISION

A. Why Is The Threshold Important?

Consider for simplicity we have only 10 images in the training set. And an image that is not in the training set comes up for the recognition task. The score for each of the 10 images will be found out with the incoming image. In addition, even if an image is not in the database, it will still say the image is recognized as the training image with which its score is the lowest. Clearly, this is a clash that we need to look at. It is for this purpose that we decide the threshold. The threshold is decided heuristically.

B. How To Choose Threshold?

Generally, threshold value is chosen arbitrarily. There is no formula for calculating the threshold value. Its value is chosen arbitrarily or taken as some factor of maximum value of minimum Euclidian distances of each image from other images. In this paper we have calculated what should be the value of threshold?

V EXPERIMENTAL RESULTS

To assess the effect of changing threshold value on the performance of human face recognition, we have performed several experiments on ORL databases using MATLAB. ORL database has images of 40 people, 10 images of each person. So in our database, there are 400 images total.
For the testing, 69 images have taken in test database. In the test database, some faces are from training database but having different face expression. Some faces are unknown faces which do not exist in training database. Some images are non-faces.

For result evaluation, recognition rate is taken as performance metric. Here recognition rate is defined as ratio of successfully recognized test images to the total number of test images. E.g. there are 100 test images out of which it recognizes 60 test images successfully i.e. whether they are known faces or unknown faces, and then recognition rate is 60%.

From the observations and graph, it is clear that if the threshold value is taken as 0.8 times of the maximum value of minimum Euclidian distances of each image from other images i.e. (θ=0.8*max(e)) , recognition rate is more in every observation as compared to the case when threshold is taken as maximum value of minimum Euclidian distances i.e. (θ = max(e)).

No.of Eigenfaces	θ = max(e) Recognition Rate (%)	θ = 0.8 * max(e) Recognition Rate (%)
10	84	94
20	90	96
30	90	97
40	91	97
50	94	97
60	94	97
70	94	97
80	94	97
90	93	97
100	93	97
110	93	97
150	93	97
180	93	97
190	91	96
200	90	96

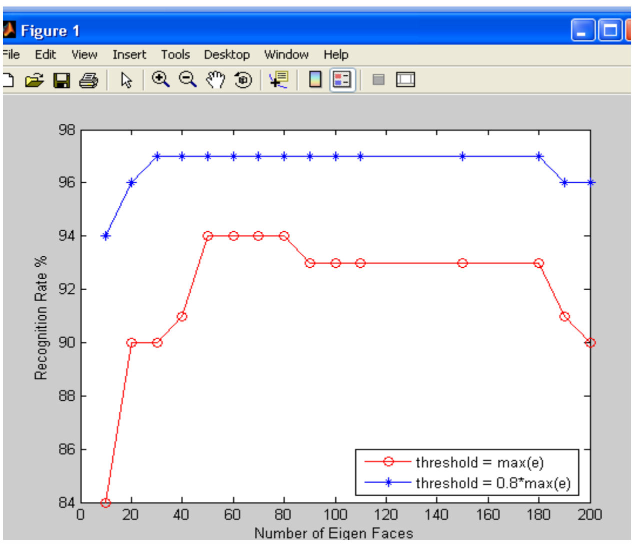

Figure-1

Also it is clear from the observations that as the number of eigen faces are increasing, recognition rate goes on increasing.

VI CONCLUSION

Highest recognition rate is achieved when 15% of eigenfaces are taken with threshold value equal to 0.8 times of the maximum value of minimum Euclidian distances. A recognition rate of 97% is achieved.

Face recognition has become an important issue in many applications such as security system, credit card verification and criminal identification. For example, the ability to model a particular face and distinguish it from a large set of stored face model would make it possible to vastly improve the criminal identification. Even the ability to merely detect faces, as apposed to recognizing them, can be important.

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