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Face Recognition using Principal Component Analysis

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Abstract—*In the current paper, we worked on problem of the face recognition system by using Principal Component Analysis. The PCA is based on KLT transform, which helps to reduce the dimensionality of data components. In this technique training set, consist of images are defined as a linear combination of weighted eigenvectors which are known as eigenfaces. These eigenfaces are obtained by using co-variance matrices of the trained dataset. The weights are determined after selecting a set of most relevant eigenfaces. Recognition is performed by projecting a test image onto the subspace spanned by the eigenfaces and then classification is done by measuring minimum Euclidian distance. If the distance is less than threshold value, the face is known otherwise result cannot predicted.Lot of experiments have done to perform the face recognition system. In this paper, we conducted various simulations to verify our algorithm. A considerable accuracy is reported through the same.*

Keywords*: PCA, eigenvectors, eigenfaces, training dataset, average face, Euclidian distance.*

1. INTRODUCTION

Face recognition has become a popular area of research from last 20 years or more in field of computer vision and one of the most successful application of image processing and understanding. Not only computer science researchers, but also neuroscientists and psychologists are interested in it, because this technology makes neuroscientists and psychologists eager about the working of humanbrain and vice versa[1]. The target is to implement the system model for a particular face and differentiate it from a huge number of faces with some variation. It provides us the better wayto find out the lowerdimensional space. Further this algorithm can be extended to recognize the facial expression and gender of a person as well. Recognition could be done under various conditions like frontal view, subject with beard, cap, spectacles etc. are tried. The main purpose of this paper is to study and create a suitable Matlab program for face recognition using Principal Component Analysis method and to perform test for program optimization and accuracy as well. This method is preferred due to its capability of speed, learning, and simplicity[2].

2. PROCESS OF FACE RECOGNITION

The Eigenface is one of the most effective PCA approach in face recognition. This approach transforms the image components into the lower dimensional space. When a new image in the eigenface subspace is projected, the recognition process takes place, after which the person is classified by comparing its position in eigenface space with the position of known individual [3]. The main advantage of this process is its speed, simplicity and efficiency to small or gradual changes on the face.

The whole recognition process categories into two parts.

(i) Initialization process
(ii) Recognition process

The initialization process consists of following steps.

(a) Acquire the training dataset of images.
(b) Calculate the eigenfaces from the dataset, only keep the highest eigenvalues. These images from 1 to m are the face space.
(c) By projecting his or her face images onto this face-space, calculate the distribution in this m-dimensional space for each known person.

After initialize the system, the next process having the following steps :-

(a) Calculate the weight based on the input image and m eigenfaces by projecting the input image onto the every eigenfaces.
(b) Check, if the face image is sufficient close to a "free space" and determining if the image is a face at all (known or unknown).
(c) Classify the weight pattern as known or unknown, if it is a face.

3. EIGENFACE ALGORITHM

An image may also be considered as a vector of m×n, so a typical face image of size 112×92 is equivalent of 10304 dimensions.

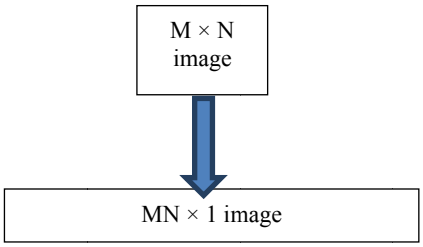


Fig. 1: Conversion of M×N image into MN×1 vector.

Step1:Prepare and obtain the training dataset.I_1,I_2,I_3……..…..I_m(trained faces). The face image must be centered and same size.

Step 2: Prepare the dataset as every face image is transformed into a vector and placed into a training dataset S.

$$\mathbf{S}=\{\Gamma_1,\Gamma_2,\Gamma_2\text{……..}\Gamma_m\}$$

In our example m=400 in vector form of size MN×1 and placed into the dataset. For better understanding and simplicity the face image are assumed to be of size N×N=N^2 dimensional space.

Step 3: Calculate the average face vector. The average face vector (Ψ) formula:

$$\Psi = \frac{1}{M}\sum_{n=1}^{M}\Gamma_n .$$

Step4: Subtract the average face vector to find out the mean image:

$$\Phi_i = \Gamma_i - \Psi$$

Step 5: Now calculate the covariance matrix to generate eigenfaces by following manner :-

$$C = \frac{1}{M}\sum_{n=1}^{M}\Phi_n\Phi_n^T = AA^T .$$

WhereA = {Φ_1,Φ_2,Φ_3,……

Step 6: Calculate the eigenvectors and eigenvalues of covariance matrix:

This matrix C in step 5 has $N^2\times N^2$ dimensionality. So if N=100 then 10000×10000 = 100000000 dimensions, that is huge size.

⟶ Not practically!!!!

So consider this matrix as A^TA (M×M). Now if M=100 then 100 × 100 = 10000.

Step 7: Convert lower dimension K eigenvector to original face dimensionality.

$$U_i = Av_i$$

Select the best K eigenvectors and assign the weight for every image in the dataset.

w_1

$\Omega_i = w_2$

w_3

w_k

Fig. 2: Weight vectors for eigenfaces.

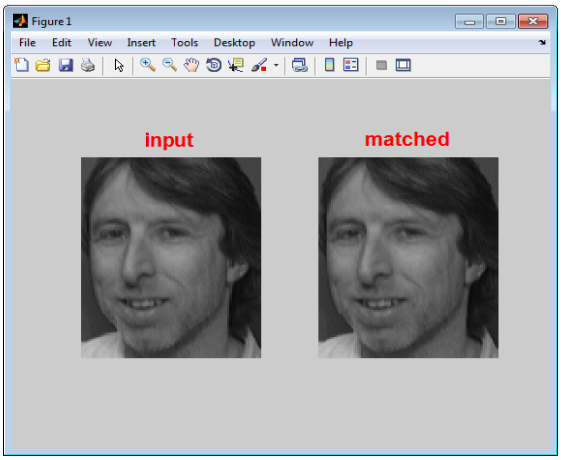
Each face from trainingdataset can be represented a weighted sum of the K eigenfaces. Calculate distance between input weight vector and all the weight vector of training set.

Step 8 : If distance is less than threshold the face is known otherwise unknown or result cannot predicted.

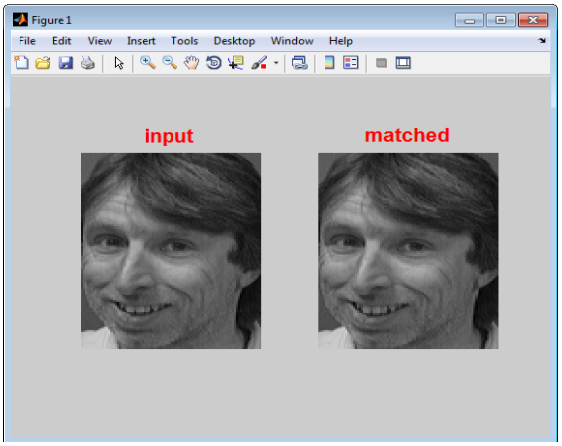
4. EXPERIMENTAL RESULT

This paper represents some computational result in matlab. The result shows both, similar poses and different poses with different characters.

Result-1(same pose)



Result-2(pose variation)



Result-3(pose variation)

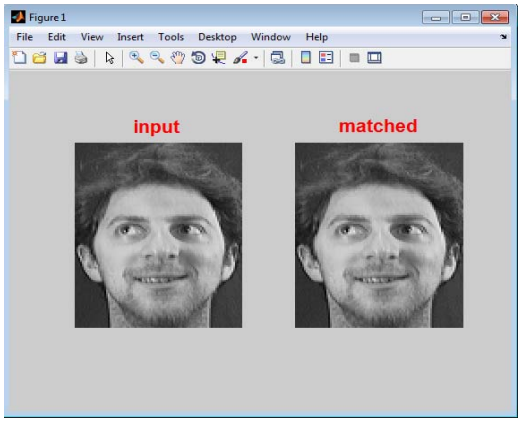


Fig. 3: The recognition result with similar poses and pose variation.

5. CONCLUSION

In this paper, we performed the PCA technique for face recognition, which has given a better result with similar and different pose variation. In this experiment we used the ORL database with pgm images and implemented in matlab. This method gave better result though it has limitations over the variations in size of images. Thus, this technique is a good solution for face recognition challenge. It is a simple, fast and shown work well in constrained environment.

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