FACE RECOGNITION USING PRINCIPAL COMPONENT ANALYSIS

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Abstract

This paper mainly fabricates the face recognition system and presents an experimental performance of face recognition using Principal Component Analysis (PCA) and Normalized Principal Component Analysis (NPCA). PCA involves wrenching out the features and then recognizing it, nevertheless of ageing, occlusion, expression, illumination and pose to recognize the faces. Face images are projected onto a face space that encodes and produces best variation among known face images. In PCA, every image in the training set is represented as a linear combination of weighted eigenvectors called eigenfaces. These eigenvectors are obtained from covariance matrix of a training image set. The weights are found out 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 Euclidean distance.

Keywords: Normalized PCA, Eigenface, Eigenvectors, training set, covariance matrix, subspace, and Euclidean distance.

I.INTRODUCTION

Security and authentication of a person is a crucial part of any industry. There are many techniques used for these purpose one of them is face recognition. Face recognition has been an active research area in the pattern recognition and computer vision domains. Face is a complex multidimensional structure and needs good computing techniques for recognition. The face is our primary and first focus of attention in social life playing an important role in identity of individual. Facial features are extracted and implemented through algorithms which are efficient and some modifications are done to improve the existing algorithm models. In the field of face recognition, the dimension of the facial images is very high and require considerable amount of computing time for classification. Classification and subsequent recognition time can be reduced by reducing dimension of the image data. PCA not only reduces the dimensionality of the image, but also retains some of the variations in the image data and provides a compact representation of a face image. The key idea of the PCA method is to transform the face images into a small set of characteristics feature images, called eigenfaces, which are the principal components of the initial training set of the face images. The face features are extracted by the PCA method, reducing the dimensionality of input space. It has been seen that variations between the images of the same subject due to variation in pose, orientation, etc. are quite high. Therefore, to achieve high recognition rate, structural information of face images of the same subject is considered for classification process. It has many potential applications, such as, surveillance, credit cards, passport, security, etc.

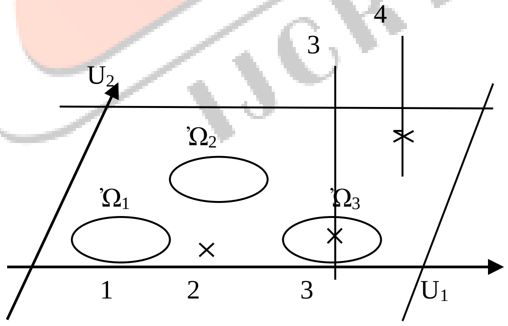
A. Eigen Face

Eigen faces are a set of Eigen vectors used in the Computer Vision problem of human face recognition. The Eigen faces are Principal Components of a distribution of faces, or equivalently, the Eigen vectors of the covariance matrix of the set of the face images, where an image with N by N pixels is considered a point in N^2 dimensional space.

In linear algebra, the eigenvectors of a linear operator are non-zero vectors which, when operated by the operator, result in a scalar multiple of them. Scalar is then called Eigen value associated with the eigenvector (X). Each image location contributes to each Eigen vector, so that we can display the Eigen vector as a sort of face. Each face image can be represented exactly in terms of linear combination of the Eigen faces. The number of possible Eigen faces is equal to the number of face image in the training set. The faces can also be approximated by using best Eigen face, those that have the largest Eigen values, and which therefore account for most variance between the set of face images.

B. Face Image Representation

Face space is a theoretical idea in psychology such that it is a multidimensional space in which recognisable faces are stored. The representation of faces within this space is according to invariant features of the face itself. Training set of 'm' images of size N X N are represented by vectors of size N^2.Each face is represented by$\Gamma_1,\Gamma_2,\Gamma_3, \ldots,\Gamma_M$. Feature vector of a face is stored in a NXN matrix. Now, this two dimensional vector is changed to one dimensional vector.



C. Various distance metrics

There are two different distance metrics used to relate the eigen feature vectors. They are:

(i) Mahalanobis Distance

Mahalanobis space is defined as a space where the sample variance along each dimension is one. Therefore, the transformation of a vector from image space to feature space is performed by dividing each coefficient in the vector by its corresponding standard deviation.

(ii) Manhattan Distance

It is also known as the L1- norm or the Manhattan Distance or the City Block Distance. It is defined as follows:

$$d(x,y) = |x-y| = \sum_{i=1}^{k}(x_i-y_i)^2$$

(iii) Euclidean Distance

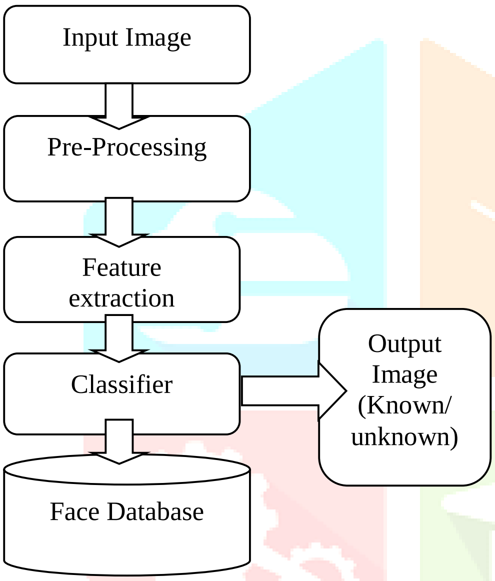
It is also known as the L2-norm or Euclidean Distance. It is the ordinary straight line distance between two points in Euclidean space. With this distance, Euclidean space becomes a metric space. The associated norm is called the Euclidean norm. This distance is used in the concept of eigen faces. It is defined as follows:

$$d(x,y) = ||x-y||^2 = \sum_{i=1}^{k}(x_i - y_i)^2$$

II. STEPS IN RECOGNITION PROCESS

A pattern recognition task performed exclusively on faces is termed as face recognition. It can be described as classifying a face either known or unknown, after matching it with stored known individuals as a database.

There are five main functional blocks, whose responsibilities are as below.



The simplest form of PCA approach is eigen face approach. This approach transforms faces into small set of characteristics called eigenfaces.

Recognition is done by projecting a new image in the eigenface subspace, after which the person is classified by comparing its position in eigen face with the position of known individuals. The advantage of this approach over other face recognition systems is in its simplicity and in-sensitivity to small or gradual changes on the face.

The whole recognition process involves two steps:

(1) Initialization process
(2) Recognition process

The Initialization process acquire the initial set of faces and calculate the eigen faces and select M images and project his or her face images on to this face-space.

In recognition process calculate a set of weights based on input images and check if the image is a face at all (known or unknown).

Below Four modules illustrates the various steps involved in recognizing process:

A. The Acquisition Module

This is the entry point of the face recognition process. The user gives the face image as the input to face recognition system in this module.

B. The Pre-Processing Module

In this module the images are normalized to improve the recognition of the system. The pre-processing steps implemented are as follows:

- Image size normalization
- Background removal
- Translation and rotational normalizations
- Illumination normalization

C.The Feature Extraction Module

After the pre-processing the normalized face image is given as input to the feature extraction module to find the key features that will be used for classification. The module composes a feature vector that is well enough to represent the face image.

D. The Classification Module

With the help of a pattern classifier, the extracted features of face image are compared with the ones stored in the face database.

III. FACE RECOGNITION ALGORITHM

Raw face image may consume a long time to recognize since it suffers from a huge amount of pixels. One needs to reduce the amounts of pixels. This is called dimensionality reduction. Feature extraction refers to transforming face space into a feature space. In the feature space, the face database is represented by a reduced number of features that retain most of the important information of the original faces. The most popular method to achieve this target is through applying the PCA algorithm. In contrast to linear PCA, N-PCA has been developed.

A. Principal Component Analysis (PCA)

The PCA approach is applied to reduce the dimension of the data by means of data compression, and reveals the most effective low dimensional structure of facial patterns. The advantage of this reduction in dimensions is that it removes information that is not useful and specifically decomposes the structure of face into components that is it can trim down the data required to recognize the entity to 1/1000th of the data existing. The training image that is the closest to the test image will be matched and used to identify. Calculate relative Euclidean distance between the testing image and the reconstructed image of i^{th}person, the minimum distance gives the best match.

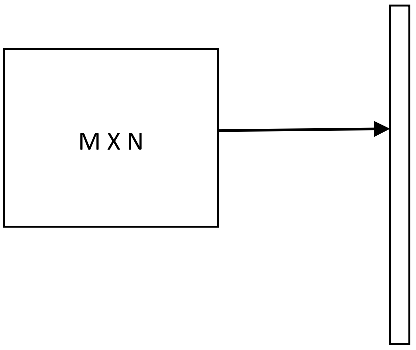
B. Normalized Principal Component Analysis (N-PCA)

In contrast to linear PCA, N-PCA has been developed to give better results in terms if efficiency. NPCA is an extension over linear PCA in which firstly normalization of images is done in order to remove the lightning variations and background effects and singular value decomposition (SVD) is used instead of eigen value decomposition (EVD), followed by the feature extraction steps of linear PCA and lastly in classification steps, weights are calculated for matching purpose.

IV.IMPLEMENTATION

Converting image into a vector:

Let a face image Γ(x, y) be a two dimensional M by N array of intensity values. An image may also be considered as a vector of dimension M × N, so that a typical image of size M X N becomes a vector of dimension MN or equivalently a point in a MN dimensional space.



MN X 1

Prepare the training faces: Obtain face images I1, I_2, I_3, I_4 , ... I_M (training faces). The face images must be centred and of the same size.

Preparing data set: Each face image I_i in the database is transformed into a vector and placed into a training set.

$$S=\{\Gamma_1, \Gamma_2, \Gamma_3, \ldots \Gamma_n\}$$

For simplicity, the face images are assumed to be of size N × N resulting in a point in dimensional space.

Compute the average face vector: The average face vector (Ψ) has to be calculated as:

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

Obtain normalized face: The average face vector Ψ is subtracted from the original faces Γ_i and the result stored in the variable Φ_i

$$\phi_i = \Gamma_i - \Psi$$

Obtain covariance matrix:

$$C = \frac{1}{M}\sum_{n=1}^{M} \phi_n \phi^T_n = A\,A^T$$

is$(N^2 X N^2)$ Matrix Where,

$$A=[\phi_1, \phi_2, \phi_3, \phi_4, \ldots\ldots \phi_M]$$

(N^2 X M matrix)

Calculate the eigenvectors and eigen values of the covariance matrix

Compute the eigenvectors of u_i of AA^T
The matrix AA^T is very large→ not practical!!!

(i)consider the matrix
$$L=A^TA(M \times M \text{ matrix})$$
(ii)compute eigenvectors v_i of L= A^T A
$A^T A v_i = \mu_i v_i$
What is the relationship between u_i and v_i ?
$$A^T A v_i = \mu_i v_i$$
$$A A^T A v_i = \mu_i A v_i$$
Note 1: C = AA^T and L= A^T A can have upto$_N{}^2$eigenvalues and eigenvectors.
Note 2: L= A^T A can have upto M eigen values and eigenvectors.
Note 3: The M eigenvalues of C=A A^T (along with their corresponding eigenvectors) correspond to the M largest eigenvalues of L= A^T A (along with their corresponding eigenvectors).

Where v_i is an eigenvector of L =. From this simple proof we can see that A v_i is an eigenvector of C = AA^T . The M eigenvectors of L = A^TA are used to find the M eigenvectors u_i of C that form our eigenface basis:

$$u_i=\sum_{i=1}^{M} v_i \emptyset_i$$

Where, u_i are the Eigenvectors i.e. Eigenfaces.

Selecting 'K' eigen vectors: Keep only K eigenvectors (corresponding to the K largest eigenvalues) Eigenfaces with low eigenvalues can be omitted, as they explain only a small part of Characteristic features of the faces.

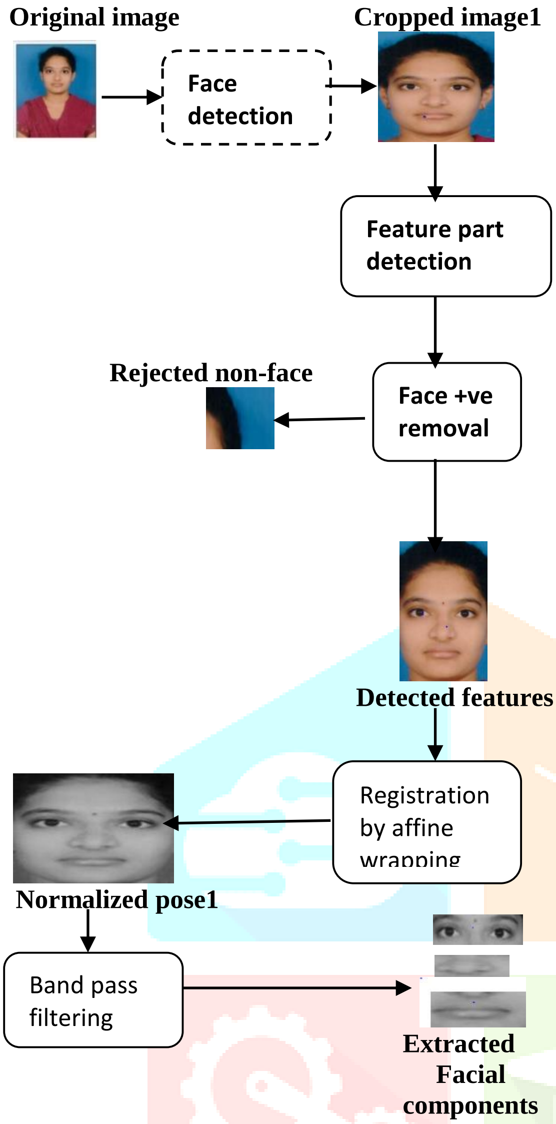
V.COMPARING THE RESULTS OF PCA AND N-PCA

The experiments have been performed on ORL database with different number of training and testing images. In the experimental set-up, the numbers of training images are varied from 80 percent to 40 percent that is initially 80% of total images is used in training and remaining 20% for testing. The experimental result shows that as the number of training images increases, efficiency of the system increases. The accuracy of face recognition algorithm was measured by Euclidian distance between the test face and all train faces. The performance of the proposed feature extraction scheme (N-PCA) is compared with PCA in terms of percentage of recognition by varying the database ratio training and testing and the results.

Train / TPD	Data Set	ORL
80/20	N-PCA	93.75
	PCA	92.50

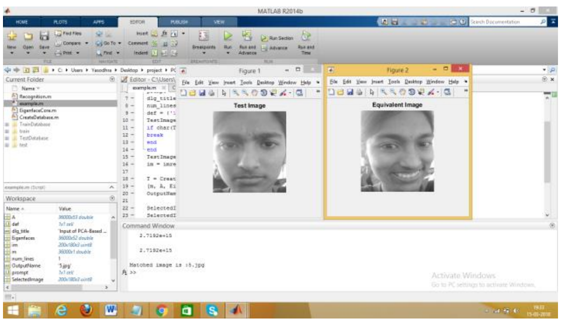
Tab. 1 Accuracy for N-PCA compared with PCA on different number of training and testing images.
*TPD: Test Percentage of Database.

VI.ARCHITECTURE DIAGRAM

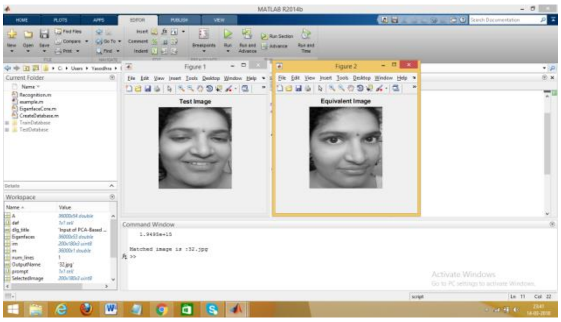


VII.RESULTS

We consider face with different poses, orientation etc. and compare these figures with the face in the data base and those with less difference between them are said to be matched.



Each face has certain eigen value which is compared to the input value and is display in the command prompt.



VIII.CONCLUSION

We implemented the face recognition system using Principal Component Analysis and Eigenface approach. The system successfully recognized the human faces and worked better in different conditions of face orientation. The algorithm has been tested for the image database ORL implemented using MATLAB. The tests conducted on Bitmap images, PNG images and JPEG images of various subjects in different poses showed that this method gave very good classification of faces though it has limitations over the variations in size of image. It is relatively simple and has been shown to work well in constrained environment.. Instead of searching large database of faces, it is better to give small set of likely matches. By using Eigenface approach, this small set of likely matches for given images can be easily obtained. The face recognition system consists of two important steps, the feature extraction and the classification.

IX.REFERENCES

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