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## FACE RECOGNITION SYSTEM

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**Abstract:** Face recognition presents a challenging problem in the field of image analysis and computer vision. A lot of work has been done on different features of faces using number of variety of algorithms, related to face recognition. But at the end, one difficulty is remaining-handling of the variations in expression, pose, and illumination when only a limited number of training samples are available. Though it is a dimensionality reduction approach, existing PCA-based face recognition systems are hard to scale up because of the computational cost and memory-requirement burden. In this paper, face recognition is done by Principal Component Analysis (PCA) and by Discrete Cosine Transform (DCT). Also, an Improved Principal Component Analysis (IPCA) is proposed for face recognition which is related to direct PCA face creation using eigenvalues and eigenvectors instead of forming an eigenface. The proposed method is tested on ORL face database and self-database. Euclidean distance is used for the recognition procedure. The same algorithm is developed using MATLAB which is an efficient tool.

Keywords: face recognition, principal component analysis, eigenvalues, eigenvectors, PCA faces.



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## INTRODUCTION

### 3. AIMS AND OBJECTIVES

#### 3.1 Aim

To develop and implement a robust technique for human face recognition based on Principal Component Analysis (PCAfaces approach)

#### 3.2 Project Objectives

1. Study the basic concepts of pattern and face recognition problem and their relevance in digital image processing.
2. Study the different approaches to face recognition problem: Feature based recognition and Principal Component Analysis (PCA) method.
3. Develop different steps involved in face recognition using PCA -PCAface approach.
4. Simulate and implement the developed algorithm using MATLAB software with standard test image databases.

#### PCA THEORY:

Principal component analysis in signal processing can be described as a transform of a given set of  $n$  input vectors each of length  $K$  formed in the  $n$ -dimensional vector  $x = [x_1, x_2, \dots, x_n]^T$  into a vector  $y$  according to

$$y = A(x - m_x)$$

Each row of  $x$  have  $K$  variables belonging to one input.

$m_x$  represents the mean or expectation of all input variables defined as:

$$m_x = E[x] = \frac{1}{K} \sum_{k=1}^K x_k$$

The matrix  $A$  in the above equation is derived from the covariance matrix  $C_x$ . Rows of the matrix  $A$  are the eigen vector of the covariance matrix arrange according to the decreasing order of their eigen value.

The covariance matrix is given by:

$$C_x = E\{(x - m_x)(x - m_x)^T\} = \frac{1}{K} \sum_{k=1}^K (x_k x_k^T - m_k m_k^T)$$

As  $x$  is a  $n$  dimensional vector so  $C_x$  is a  $n \times n$  vector where each element is given by:

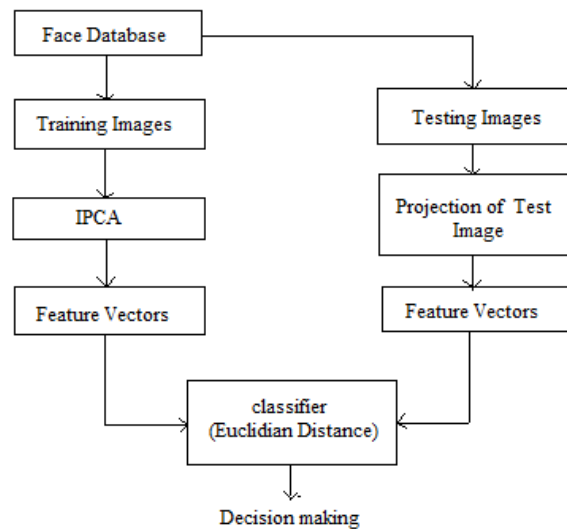
$$C_x(i, j) = E\{(x_i - m_i)(x_j - m_j)\}$$

Rows of  $A$  are orthogonal to each other. We choose the number of rows to be present in  $A$ , which is less than or equal to  $n$ , and represent the dimension to which we want to reduce  $y$ .

#### 4. IPCA ALGORITHM

##### 4.1 Training the system

- 1) Acquire the set of face images known as the training set. Basically the images in the training set are of size  $M \times N$  so we have to represent the original images in the form of vectors i.e., of the size  $MN \times 1$ .
- 2) Let us denote these vectors as  $\Gamma_1, \Gamma_2, \dots, \Gamma_p$ , where  $p = \text{no of images in the training set}$ .
- 3) Now find the average face of the above set by using the formula  $\Psi = (1/N) \sum_{i=1}^p \Gamma_i$ .  $\Psi$  is the mean image with dimensions  $MN \times 1$ .
- 4) The centered images are found by  $\Phi_i = \Gamma_i - \Psi$  where  $i = 1..p$ .
- 5) The Covariance matrix is constructed as  $C = A \cdot A^T$ , where  $A = [\Phi_1, \Phi_2 \dots \Phi_p]$ , the dimensions of  $C$  is  $MN \times MN$ , here we can observe that the dimensionality is very high so let us take the reverse case as  $C = A^T \cdot A$  so that dimensionality has been reduced to  $p \times p$ .
- 6) Now obtain the Eigenvectors and Eigenvalues for the covariance matrix. Let us consider  $V$  as Eigenvector and  $U$  as Eigenvalue  $CV = UV$ .



**Fig.1. Proposed Block Diagram of IPCA**

7) Order the EigenVectors with respective to EigenValues. The difference is here. Keep all the eigenvectors associated with non-zero eigenvalues without rejecting them. This matrix of eigenvectors is the eigenspace  $N_{\text{vectors}}$ , where each column of  $N_{\text{vectors}}$  is an Eigenvector  $V = [v_1 | v_2 | \dots | v_p]$ .

8) Project the centered training images into the EigenSpace, calculate the dot product of the image with each of ordered Eigenvectors. Therefore, the dot product of the image and the first Eigenvector will be the first value in the new vector. This is the first PCA component. In this way we calculate all the 100 PCA components having dimensions  $(112 \times 92) \times 100$ . The new vector of the projected image will contain as many values as Eigenvectors. This is called as PCA face.

9) Now, take dot product of individual PCA component and first image. This value will be  $\Omega_1$ . In this way, we can find  $\Omega = \{\Omega_2, \Omega_3, \Omega_4, \dots, \Omega_{100}\}$ .

#### 4.2 Testing the system

Here the input image is given to the face recognition system for recognition.

1) The input image is converted to a vector of size  $MN \times 1$ . This vector is considered as  $\Gamma$ .

$$\Phi_{\text{input}} = \Gamma - \Psi_{\text{input}}$$

- 2) Dot product of individual PCA component and  $\Phi_{input}$ . Therefore,  $\Omega_B = \{\Omega_{B1}, \Omega_{B2}, \Omega_{B3}, \dots, \Omega_{B100}\}$ .
- 3) Calculate the Euclidean distance by using formula

$$e^2_i = || \Omega_{input} - \Omega_i ||^2$$

- 4) The image with the least Euclidean distance is considered as the closest image.

## 5. IMPLEMENTATION

### 5.1 Formation of Library face Database

Database for different set of conditions is maintained. Ten different expressions for ten different people thus creating a 10x10 that is equal to 100 different set of face images. Rotated images in left and right direction and different illumination conditions are also considered while making the training set. Size variations in an input face image can also change the output therefore input images by varying their size are also taken for recognition. Figure 3 shows a single face image for ten different expressions



Fig.3. A single face image for ten different expressions

### 5.2 Recognition and learning phase.

After choosing a training set and constructing the weight vectors of face library members, now the system is ready to perform the recognition process. User initiates the recognition process by choosing a face image.

### DCT

We have used Matlab 2011a is used for implementation. We use the same data base as the above case. The face images are cropped and changed grey level. Next we convert the image to DCT domain for feature extraction. The feature vector is dimensionally much less as compared to the original image but contains the required information for recognition. The DCT of the image has the same size as the original image. But the coefficients with large magnitude are mainly located in the upper left corner of the DCT matrix. Low frequency coefficients are related to illumination variation and smooth regions (like forehead cheek etc.) of the face. High frequency coefficients represent noise and detailed information about the eddies in the image.

The mid frequency region coefficients represent the general structure of the face in the image. Hence we can't ignore all the low frequency components for achieving illumination invariance and also we can't truncate all the high frequency components for removing noise as they are responsible for edges and finer details.

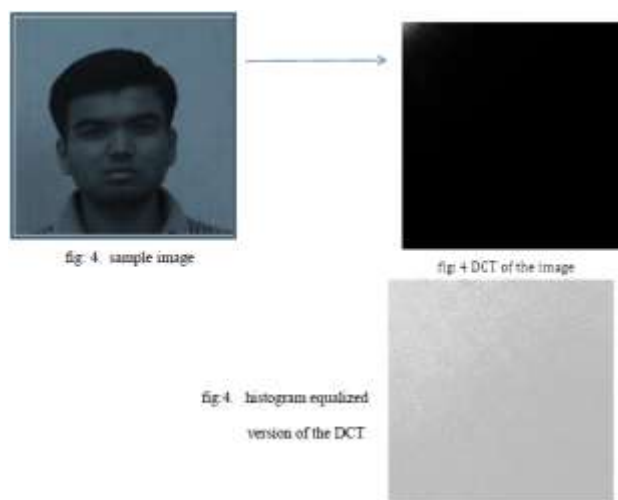
Here we are going to consider following approach for feature extraction:

**Holistic approach** (we take the DCT of the whole image)

In holistic approach we take the DCT of the whole image and extract the feature vector from it.

#### HOLISTIC APPROACH

We take DCT of the image. Here our image size is 480 x 480. Next we convert the DCT of the image into a one dimensional vector by zigzag scanning. We do a zigzag scanning so that in the vector the components are arranged according to increasing value of frequency.



Depending on the experiments done using PCA and DCT, we got the accuracy rate : 78.125% for PCA and : 80.333% for DCT

## 6. EXPERIMENTS AND RESULTS

### 6.1 Experiments

#### Face recognition using IPCA:

Size of an image plays a vital role in the recognition process. The experimental results have been obtained on ORL database and self database. Initially, the ORL database is taken for training the

system, consists of 10 objects with each having 10 poses(includes lightening conditions also).means there are 100 face images for training purpose. And for the testing I am going to use all 100 images. The primitive size in the database is 112x92.

Now, according to algorithm, first step is to find out mean image of the 100 images.

By using MATLAB code, mean image is as shown below:

The average face of the above set by using the formula  $\Psi = (1/N)\sum_{i=1}^p \Gamma_i$ .  $\Psi$  is the mean image with dimensions 112 x 92 x 1.



Fig.4. Mean Image of 100 Faces

According to the IPCA Algorithm, PCA face is shown as by using matlab:



Fig.5. PCA Face

Using GUI window:

Give the input image:

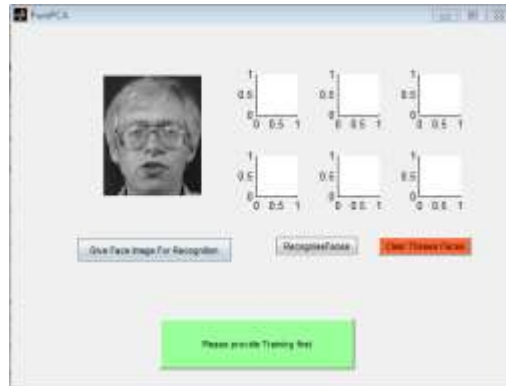


Fig. 6. Given input image



Fig. 7. Recognized faces

For giving other image, first clear these faces and then give other Image:

Next input:



Fig. 8 : input from self database



Output:



Fig. 9. output of fig.8

## 6.2 Results

According to the above experiments on ORL Database, we get following observation table 8.2.1:

Table 6.2.1 Recognized images out of 6 for 100 images

Images	Recognized images out of 6	Images	Recognized images out of 6
1	6	41	6
2	6	42	6
3	6	43	6
4	6	44	6
6	6	45	6
8	6	46	6
9	6	47	6
10	6	48	6
11	6	49	6
12	4	50	6

13	6	51	6
14	6	52	6
15	6	53	6
16	6	54	6
17	6	55	6
18	3	56	6
19	3	57	6
20	6	58	6
21	6	59	6
22	6	60	6
23	6	83	5
24	6	84	6
25	6	86	5
26	6	88	5
27	6	89	5
28	6	91	5
29	5	93	6
30	6	94	5
64	5	96	6
66	5	77	6
71	6	78	6
72	6	79	6

73	6	80	6
74	6	97	6
75	6	99	6
76	6	100	5

We get the following plot:

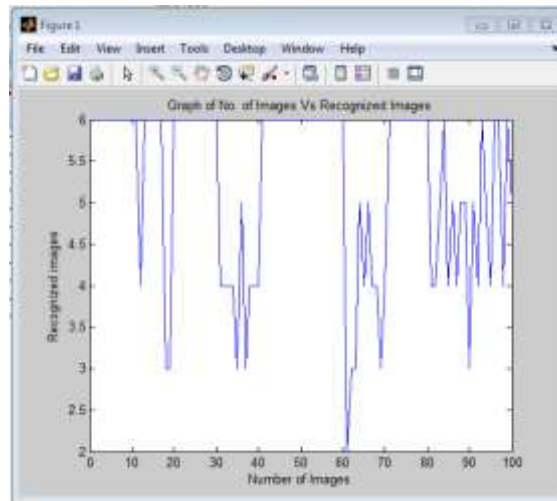


Fig.10. Graph of No. of Images Vs Recognized Images

### 6.3 Observations:

From the graph, it can be shown that out of 100:

64 images recognized correctly, that is 100 %.

11 images recognized 83.33%.

19 images recognized 66.66%.

Remaining 6 are not recognized properly.

Overall we get accuracy rate for IPCA : 94%

## CONCLUSION

In this paper, the basic PCA and DCT algorithm is introduced and depending on the limitations of these methods, a new Face recognition method is presented using Improved Principal Component Analysis (IPCA). The principal components are selected by using both eigenvectors and eigenvalues and PCA Face is formed directly without finding Eigen faces. This reduces complexity. With these eigenvectors, the input images are classified based on Euclidian distance. The proposed method was tested on ORL face database and Self-Database. As shown in the results, the proposed IPCA method has the greater accuracy with consistency than the existing method of PCA and DCT. The recognition rate is greater even with the small number of training images which demonstrated an improvement in comparison with previous methods.

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