COMPARATIVE ANALYSIS OF FACE RECOGNITION BASED ON SIGNIFICANT PRINCIPAL COMPONENTS OF PCA TECHNIQUE

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ABSTRACT

Face recognition systems have been emerging as acceptable approaches for human authorization. Face recognition help in searching and classifying a face database and at a higher level help in identification of possible threats to security. In face recognition problem, the objective is to search a face in the reference face database that matches a given subject. The task of face recognition involves the extraction of feature vectors of the human face from the face image for differentiating it from other persons [6]. In this work, the comparative analysis is done based on the varying number of highly significant principal components (Eigenvectors) of PCA for face recognition. Experimental results show a small number of principal components of PCA are required for matching. PCA technique is a statistical technique, it reduces the dimension of the search space that best describes the images.

Keywords: Covariance Matrix, Eigenvector, Eigenvalue, Euclidean Distance, ORL, PCA.

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1. INTRODUCTION

Principal Component Analysis is a technique, which uses sophisticated underlying mathematical principles to transform a number of correlated variables into a smaller number of variables called principal components [3,8]. PCA reduces the large dimensionality of the data space (observed variables) to a smaller intrinsic dimensionality of feature space (independent variables), which are needed to describe the data efficiently. PCA can do prediction, data redundancy removal, feature extraction, data compression, etc. The Principal component analysis is also known as eigenface method, in this method the images are

projected onto the facial value so called eigenspace [2,7]. The eigenvectors are ordered on the basis of eigenvalues, each one accounting for a different amount of the variation among the face images. Each image location contributes more or less to each eigenvector. PCA approach reduces the dimension of the data by means of data compression basics [1] and reveals the most effective low dimensional structure of facial patterns. This reduction in dimension removes information that is not useful [5] and precisely decomposes the face structure into uncorrelated components known as eigenfaces. This method is preferred because of its simplicity, speed and learning capability [4]. PCA is a useful statistical technique that has found application in fields such as face recognition and image compression and is a common technique for finding patterns in data of high dimension.

2. ORL FACE DATABASE

ORL face database consist of a set of faces taken at the Olivetti Research Laboratory in Cambridge, United Kingdom [10]. ORL face database has been used to benchmark in many face identifying systems. It contains a total of 400 face images of forty different persons, ten images per person. For each subject, it contains 10 face images under different facial expressions, lighting conditions and poses. All the face images are taken against a dark homogeneous background with the persons in an up-right, frontal position, with tolerance for some tilting and rotation of up to about 20 degrees. The images have a resolution of 92×112 pixels, grayscale and in bitmap file format (.bmp). There is diversity in the images of different subjects like a subject has beard, glasses, moustaches etc.

2.1. Face recognition using Principal Component Analysis (PCA)

Figure.1 shows the flowchart of a PCA based face recognition system [9]. Preliminarily some preprocessing task is done such as resizing the image size. ORL face database images size is 92×112 and after resizing the face image size is 92×92 . For implementing face recognition system based on the PCA technique [3,8], we follow the three steps: Face preprocessing, feature vector extraction and recognition step.

Figure 1 Flow chart of face recognition system based on PCA

2.2. Steps

1. A set of M training images (I1, I2, I3,..., IM) with size N×M are changed into N×N and are then represented by a column vector of size 1×N2.

2. The average (Ψ) of the training set image is calculated and is defined by the following mathematical formula:

$$\Psi = \frac{\sum_{n=1}^M T_n}{M} \quad (a)$$

3. The average face vector Ψ is subtracted from each trainee image I and stored in Φ .

$$\Phi = I_i - \Psi \text{ (Deviation From mean vector)} \quad (b)$$

4. From Φ , the Covariance Matrix “C” is calculated as follows:

$$C = AA^T \quad (c)$$

$$\text{Where, } A = [\Phi_1, \Phi_2, \Phi_3, \dots, \Phi_M] \quad (d)$$

5. Calculate the eigenvalues λ_i and eigenvectors u_i of the covariance matrix C with N2×N2 dimension and it is impractical to make such number of calculations. To reduce the number of calculations, the following steps are followed:

$$\text{Let } L = A^T A \quad (e)$$

Calculate v_i of equation-(e)

$$A^T A v_i = u_i v_i$$

$$A A^T A v_i = u_i A v_i$$

$$C A v_i = u_i A v_i \text{ from (c)}$$

$$C u_i = u_i A v_i, \text{ \{where } u_i = A v_i \} } \quad (f)$$

Hence C and L have the same eigenvalues and their eigenvectors are related by $u_i = A v_i$, Where v_i is an eigenvector of $L = A^T A$. From this simple proof, we can see that $A v_i$ is an

eigenvector of $C = AA^T$. The M eigenvectors of $L = A^T A$ are used to find the M eigenvectors of C that form our eigenface basis:

$$u_i = Av_i \quad (g)$$

Where u_i , are the eigenvectors i.e. eigenfaces.

6. The eigenvectors with high eigenvalues are retained to classify an image with the help of following formula:

$$\omega_i = u_i^T (I_i - \Psi) \quad (h)$$

Where u_i is the i^{th} eigenfaces and $i=1, 2, 3, \dots, k$. The weights are obtained as above to form a vector as follows that describes the contribution of each eigenface in representing the input face image.

$$\Omega^T_i = \{\omega_1, \omega_2, \omega_3, \dots, \omega_K\} \quad (i)$$

7. Apply the same set of steps to the query image to find:

$$\omega_{\text{query}} = u_i^T (I_{\text{query}} - \Psi) \quad (j)$$

Where u_i is the i^{th} eigenfaces and $i=1, 2, 3, \dots, k$.

$$\Omega^T_{\text{query}} = \{\omega_1, \omega_2, \omega_3, \dots, \omega_K\} \quad (k)$$

8. To determine the match, find the Euclidean distance between the query image feature vector and database image feature vectors as follows:

$$E_d = \sqrt{|\Omega^T_{\text{query}} - \Omega^T_i|^2} \quad (l)$$

9. First 10 images (as each subject has 10 poses) are displayed with minimum Euclidean distance as shown in snapshot figures.

Comparative Analysis of Face Recognition Based on Significant Principal Components of PCA Technique

Figure a, b, c, d Recognition/retrieval for one particular pose of a person using a varying number of principal components of PCA in MatLab.

3. RESULTS AND DISCUSSION

In this work of face recognition using PCA, the experimental results are obtained in MatLab on Olivetti Research Laboratory (ORL) face image database [7]. ORL face database acts as the reference face database and the experimental results are shown on 100 face images of 10 different persons with 10 poses of each person. The results are shown for various eigenvectors (principal components) with high eigenvalues to determine the match. The results show that from a huge number of eigenvectors (principal components) a small number of significant eigenvectors are required to determine a match between the query image and the database images.

Table 1 Face Recognition rate of PCA with varying number of Principal Components

No. of Principal Components	Recognition Rate (%)
1	46.3
2	71.6
3	76.3
4	84.7
5	84.9
6	85.2
7	86.8
8	87.1
9	87.1
10	87.1
11	87.0
12	87.1
13	87.2
14	87.3
15	87.4
16	87.4
17	87.3
18	87.3
19	87.3
20	87.3
21	87.2
22	87.2
23	87.2
24	87.2
25	87.2
26	87.2
27	87.2
28	87.2
29	87.2
30	87.2

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Figure 2 Graphical view of results obtained using PCA at different No. of Principal Components.

4. CONCLUSION

In this work, the face recognition system using PCA (Principal Component Analysis) method is implemented in MatLab. The recognition rate is determined on a varying number of principal components and experimental results show that a few significant numbers of principal components are required to determine more than 85% of the total recognition rate. This clearly indicates that we only require a small number of eigenvectors to determine the similarity between a query image and database images.

4.1. Future Scope

This work can be extended to work on a huge set of database images, real time imaging and videos. Moreover, the results of this work can be compared with other different face recognition techniques. In addition to this technique can be fused with artificial neural networks techniques to improve the overall recognition rate.

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