Analysis of Face and Fingerprint Based Biometric System Using Traditional Approaches

[1]Suchetha N V, [2]Sunitha N V
[1]Assistant Professor, [2]PG scholar
Department of Computer Science &Engineering
SDMIT, UJIRE, KARNATAKA

Abstract: In this paper we study an efficient face and fingerprint recognition system using two methodologies discrete cosine transform (DCT) and principal component analysis (PCA). The experimentation is done on the standard datasets, such as ORL, UMIST for face and FVC dataset for fingerprint. From the trial result, it is demonstrated that DCT based system has enhanced recognition rate than PCA approach.
Key words: DCT, PCA.

I. INTRODUCTION

This is the time of data innovation. With expanding degree of using the information technology, there is a requirement for securing the assets and keeping up the identity of the user. One of the techniques for accomplishing security is utilization of biometric system. The method of identifying a person based on their physiological and behavioral characteristics is known as biometric technology. The physiological attributes incorporates iris, face, palm print, fingerprint, DNA and so forth and behavioral attributes incorporates voice, signature, gait and so on. There are two modes of operation of biometric system i.e. verification mode and identification mode. In verification mode individual is recognized by comparing the captured biometric information and its own biometric templates. The system recognizes the individual via looking the templates of the whole user from the database in identification mode [1].

Finger impressions are used to recognize the person in fingerprint biometric system. Face recognition technology recognizes the person face from image or video [2]. Different strategies for face and fingerprint recognition are introduced in literature. To extract effective features and to reduce complexity of computation dimensionality reduction techniques are required. Discrete cosine transform (DCT) [3], linear discriminative analysis (LDA) [4], principal component analysis (PCA) [5][6] are the mainly used dimensionality reduction and feature extraction techniques. PCA is built on Eigen face approach and it's working on vectors. There are few variations of PCA, for example, Kernel PCA [7], modular PCA [8], and independent component analysis [9]. DCT transforms the images from the spatial domain to the frequency domain. In lower frequencies most of the energy is concentrated, so by converting images to its frequency components we can reduce the amount of data needed to depict the image. Certain standardization strategies can enhance the robustness of the DCT based recognition [10].

In this paper we have made an attempt to study the PCA and DCT based face and fingerprint recognition system. The experimentation is performed on the slandered datasets like ORL, UMIST face dataset & FVC fingerprint dataset. The rest of the paper is organized as follows: PCA is discussed in section II, DCT in section III, experimental results are presented in section IV, and conclusion is in section V.

II. PRINCIPAL COMPONENT ANALYSIS (PCA)

PCA is referred to as the utilization of Eigen faces, it's developed by Kirby and sirivich in 1988 [5]. PCA reduces the dimension of the image by means of compression. This dimensionality reduction removes the unwanted information and decomposes the image into Eigenvectors. Each image may be represented as a weighted sum of the Eigen faces it’s stored in 1D array. Then test image is compared against train images by measuring the distances between their respective feature vectors. The benefit of this strategy is that it can reduce the information needed to recognize the persons to 1/1000th of the information presented.

Steps to perform PCA

1. Arrange the information set
   The data are arranged as a set of n data vectors x1…xn. Write x1…xn as row vectors, each of which has p columns. Put the column vector into a single matrix X of dimensions n*p.
2. Compute experimental mean
   Compute the experimental mean along each column j=1,… ,p, then put the calculated mean values into an empirical mean vector u of dimensions p*1.

$$u[j] = 1/n \sum_{i=1}^{n} X[i,j]$$

3. Find the deviations from mean
   Subtract the empirical mean vector u from each row of the data matrix X. Store mean-subtracted data in the n*p matrix B.
   $B=X-hu^T$, where h[i]=1 for i=1,…,n.
4. Find covariance matrix
   C=1/n-1B*.B
5. Get eigenvectors and eigenvalues of the covariance matrix.
6. Reorder the eigenvectors and eigenvalues.
7. Calculate the cumulative energy content for each eigenvectors.
8. Select a subset of the eigenvectors as premise vectors.
9. Mean-subtracted images are assigned into the eigen space using retained eigenvectors.

III. DISCRETE COSINE TRANSFORM (DCT)

Discrete cosine change is a capable change to separate appropriate components. It expresses a finite sequence of data points in terms of sum of cosine functions oscillating at different frequencies. After applying DCT to entire image, a portion of the coefficients are chosen to construct feature vectors. Most conventional approach to select coefficients is in a zigzag manner.

In DCT based approach more effective frequency components are extracted as feature vector. In classification stage feature vector of train and test images are compared using Euclidean distance. Train image with minimum distance is used for classify the test image. Given nxm image, 2D n by m DCT is defined as follows:

$$F(x,y)=\alpha(x)\alpha(y)\sum_{i=0}^{n-1}\sum_{j=0}^{m-1} f(i,j)\cos\left[\frac{x(2i+1)\Pi}{2n}\right]\cos\left[\frac{y(2j+1)\Pi}{2m}\right]$$

$\alpha(x)=\sqrt{1/n}$ for x=0

$=\sqrt{2/n}$ for x=1,2,..,n-1

$\alpha(y)=\sqrt{1/m}$ for y=0

$=\sqrt{2/m}$ for y=1,2,…,m-1

Steps involved in the process:

1. Read the test image.
2. Extract the features of the test image.
3. Compare the features of test image with train image using Euclidean distance; test image with minimum distance is used for classification.
4. Based on the comparison decide whether the person is authorized or not.

IV. EXPERIMENTAL RESULTS

We have conducted experiments for face and fingerprint. Experimentation consists of three standard datasets, ORAL, UMIST for face and FVC for fingerprint. ORL dataset consists of 200 face images of 40 persons with 10 samples of each. Each sample represents small variations in expression, illumination and pose. The images are resized to 90 x 90. UMIST dataset consists of face image of 20 persons with varying number of samples. We have considered 20 samples of each. FVC dataset consists of 4 databases i.e. db1, db2, db3, db4. All four data base consists of 80 fingerprint images of 10 persons with 8 samples of each.

The experimentation includes varying the number of train samples of ORL dataset. We have considered 1st alternate samples such as i) 2, 4, 6, 8, 10, ii) 1, 3, 5, 7, 9 for training and rest of the samples for testing. Then we have considered continuous samples such as iii) 1, 2, 3, 4, 5, iv) 6, 7, 8, 9, 10, v) 1, 2, 3, 4, 5, 6, 7, vi) 4, 5, 6, 7, 8, 9, 10 for training samples and remaining for testing.

For UMIST dataset we have considered the following experimental setups: i) 1, 3, 5, 7, 9, 11, 13, 15, 17, 19, ii) 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, iii) 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, iv) 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 for training and rest of the samples for testing.

For FVC dataset we have considered the following experimental setups: i) 1, 3, 5, 7, ii) 2, 4, 6, 8, iii) 5, 6, 7, 8, iv) 1, 2, 3, 4, v) 4, 5, 6, 7, 8, vi) 1, 2, 3, 4, 5 for training and rest of the samples for testing.

In DCT based approach we will consider topmost subset of the feature matrix. In all the experiments we recorded recognition accuracy. The recognition accuracy of PCA, DCT for face and fingerprint recognition is shown below:

Table 1: Face recognition using PCA for ORAL dataset.

Test images (No. of test images)	% of recognition rate
1, 3, 5, 7, 9 (200)	90.5%
2, 4, 6, 8, 10 (200)	89.5%
6, 7, 8, 9, 10 (200)	90%
1, 2, 3, 4, 5 (200)	91.5%
8, 9, 10 (120)	85%
1, 2, 3 (120)	88.33%

Table 2: Face recognition using PCA for UMIST dataset.

Test images (No. of test images)	% of recognition rate
2, 4, 6, 8, 10, 12, 14, 16, 18, 20 (200)	100%
1, 3, 5, 7, 9, 11, 13, 15, 17, 19 (200)	99.5%
11, 12, 13, 14, 15, 16, 17 ,18, 19, 20 (200)	93.5%
1, 2, 3, 4, 5, 6, 7, 8, 9, 10 (200)	97%

Table 3: Fingerprint recognition using PCA for FVC dataset.

Test images (No. of test images)	% of recognition rate			
	DB1	**DB2**	**DB3**	**DB4**
2, 4, 6, 8 (40)	92.5%	92.5%	85%	87.5%
1, 3, 5, 7 (40)	92.5%	92.5%	87.5%	85%
1, 2, 3, 4 (40)	82.5%	87.5%	85%	92.5%
5, 6, 7, 8 (40)	90%	95%	80%	95%
1, 2, 3 (30)	96.66%	83.33%	76.66%	90%
6, 7, 8 (30)	93.33%	93.33%	93.33%	93.33%

Table 1 shows the experimental result of face recognition for ORAL data set using PCA algorithm. The accuracy for different combination of test and train images is shown. Table 2 shows the experimental results of face recognition for UMIST data set using PCA algorithm. Table 3 shows the experimental results of fingerprint recognition for FVC dataset using PCA algorithm.

Table 4 shows the experimental results of face recognition using DCT algorithm for UMIST dataset. Table 5 shows the experimental results of fingerprint recognition using DCT algorithm for FVC dataset. Experiment is conducted for different combinations of test and train images.

Table 4: Face recognition using DCT for UMIST dataset.

Test images (No. of test images)	% of recognition rate
2, 4, 6, 8, 10, 12, 14, 16, 18, 20 (200)	100%
1, 3, 5, 7, 9, 11, 13, 15, 17, 19 (200)	100%
11, 12, 13, 14, 15, 16, 17 ,18, 19, 20 (200)	99%
1, 2, 3, 4, 5, 6, 7, 8, 9, 10 (200)	90.5%

Table 5: Fingerprint recognition using DCT for FVC dataset.

Test images (No. of test images)	% of recognition rate			
	DB1	**DB2**	**DB3**	**DB4**
2, 4, 6, 8 (40)	97.5%	92.5%	95%	95%
1, 3, 5, 7 (40)	97.5%	97.5%	95%	95%
1, 2, 3, 4 (40)	90%	100%	75%	97.5%
5, 6, 7, 8 (40)	92.5%	95%	95%	97.5%
1, 2, 3 (30)	86.66%	100%	86.66%	100%
6, 7, 8 (30)	93.33%	93.33%	100%	96.66%

PCA works on spatial domain, DCT works on frequency domain. Form the experimental results obtained we analyze that the overall recognition rate of DCT based approach is better than PCA based approach. DCT based approach resolves the illumination and pose variation to some extent.

V. Conclusion

In this paper we implemented and tested the two approaches for face and fingerprint recognition, DCT & PCA. The experiments are carried out on the standard datasets such as ORAL, UMIST, and FVC. Various experiments are conducted using the two algorithms on these datasets; it included varying the number of training samples in different possible ways.
From the experimental results we conclude that DCT based approach which works in frequency domain gives more accuracy than PCA based approach which works in spatial domain. In feature work we will try to combine face and fingerprint traits.

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