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Face Recognition Based on PCA, DCT, DWT and Distance Measure

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Abstract

Face Recognition has been identified as one of the attracting research areas and it has drawn the attention of many researchers due to its varying applications such as identity authentication, security access control human computer interaction and surveillance. In this paper, we compare different features extraction algorithms like Principal Component Analysis (PCA), Discrete Cosine Transform (DCT), and Discrete Wavelet Transform (DWT) with different types of distance measures such as Euclidean distance, Cosine distance and Correlation distance. The proposed methods are tested on ORL and Yale Face Databases.

These methods are successfully applied to face-recognition, and the experimental results on ORL database gave the good results. we found that the DWT 3rd level decomposition method is the best method with the Euclidean Distance (above 95.33% recognition rate), and the PCA gives the better results with Cosine distance and Correlation distance, The overall results show that the using of DWT method is useful for recognition.

Keywords: *Face recognition, PCA, DCT, DWT, Distance measures.*

1. Introduction

Face recognition has emerged as the one of the most active research areas in multiple disciplines such as pattern recognition, image processing and computer vision, its play an important role in various applications in identity authentication, security access control, human computer interaction and surveillance.

It involves comparing the input image with a database of face images of known individuals and how to identify the individual of the input image[11]. Computational models of face recognition, in particular, are interesting because they can contribute Not only to theoretical insights but also to practical applications. Computers that recognize faces could be applied to a wide variety of problems, Including criminal identification, Security systems, Image and film processing. Unfortunately, developing a Computational model of face recognition is quite difficult because faces are complex, multidimensional.

Generally face recognition process have two basic operations, feature extraction and classification, at the first operation of face recognition system, the extraction of features from image is one of basic importance. The feature extraction algorithms are divided into two categories: Geometrical features extraction and Statistical (algebraic) features extraction. The geometric facial features such as (eyes, nose, mouth) and their relations such as (area , distance, angles)between the features, were used for recognition purposes but the feature detection and measurement techniques were not reliable for geometric feature –based so they performed poorly even with variations in pose and illumination[11].

Statistical features extraction is usually driven by algebraic methods such as principal component analysis (PCA) [1], it is commonly used to reduce the dimensionality of images and retain most of information. The central idea behind PCA is to find an orthonormal set of axes pointing at the direction of maximum covariance in the data. It is often used in representing facial images [3]. The idea is to find the orthonormal basis vectors, or the eigenvectors, of the covariance matrix of a set of images. The lack of PCA is that it is sensitive to light and changes of expressions. Alternative algebraic methods are based on transforms such as Fourier transforms (FT), the discrete wavelet transforms (DWT) and discrete cosine transforms (DCT). Transformation based feature extraction methods such as the DCT and DWT were found to generate good accuracies with very low computational cost [7].

DCT is one of the approaches provides a wide range of applications such as image coding, data compression, feature extraction .Since DCT is real-valued, it provides a better approximation of a signal with fewer coefficients, The Discrete Cosine Transform often called simply expresses a sequence of data points in terms of a sum of cosine functions oscillating at different frequencies [4]. The wavelet transform is used almost as widely as analyze signals and images[7]. Its ability to capture localized time-frequency information of image motivates its use for feature extraction. The advantage of wavelet transform, it is that divides the information of an image into decomposing images to approximate sub signals (LL) and detail sub signals (LH, HL, HH). This enables to isolate and manipulate the data with specific properties [5].

In the second operation, we classify the input face image by comparing it with database of stored known faces in order to identify the individual of input face image by using the classification algorithms [7]. We used distance measures specially, Euclidean distance, Cosine and Correlation methods. It has been shown to yield good generalization performance on a wide variety of classification problems. The face recognition system has the following components [10]:

Figure 1. Face recognition model.

2. Collect Data

All experiments were conducted using ORL face database and Yale face database. The ORL training database [14] contains 150 images of 30 persons (5 images per each person); the database test has 150 images of different individuals. All photos have dimensions 92×112 and a dark homogeneous background, and the subject is photographed in an upright and frontal position. All images are grayscale the images were taken at different times, varying lighting slightly, facial expressions (open/closed eyes, smiling/non-smiling) and facial details (glasses/no-glasses) [6, 14]. The subject is shown in Figure 2.

Figure 2. The ORL database.

The Yale database [13] contains 150 images of 15 subjects. There are 10 images per subject, one for each of the following facial expressions or configurations: center-light, with glasses, happy, left-light, without glasses, normal, right-light, sad, sleepy, surprised, and wink. The subject is shown in Figure 3.

Figure 3 .The Yale database.

The Data Base of this work is taken from ORL face database and Yale face database. There are ten different images of each of 10 distinct persons. 5 images for test and the other 5 images for recognition. In the training phase the data of the extracted features of the face will be saved and the model will be designed for the selecting classified method. In the classification phase, the Distance measure methods will be used to classify the features of specific person. After the classification is done the evaluation stage is used for result's assessment.

3. Choose Features

In this section we discuss the methods of features extraction such as PCA, DCT and DWT methods. The results of applying these methods on the face images will be the face features, which are useful for face classification. In our paper we have used comparison between these methods to get better results.

3.1 Principle Component Analysis (PCA)

PCA is known as the best data representation in the least-square sense for classical Recognition. It is commonly used to reduce the dimensionality of images and retain most of information [8]. The characteristic features are called eigenfaces in the facial recognition domain (or principal components generally). They can be extracted out of original image data by means of a mathematical tool called Principal Component Analysis (PCA) [12, 1]. The training database consists of M images which is same size. The images are normalized by converting each image matrix to equivalent image vector Γ_i the training set matrix Γ is the set of image vectors with

$$\Gamma = [\, \Gamma_1\, \Gamma_2 \ldots\ldots \Gamma_M] \quad (1)$$

The mean face ψ is the arithmetic average vector as given by:

$$\Psi = \frac{1}{M}\sum_{i=1}^{M} \Gamma i \quad (2)$$

The deviation vector for each image Φ_i is given by:

$$\Phi_i = \Gamma_i - \psi \qquad i=1,2,\ldots.M \quad (3)$$

Consider a difference matrix $A= [\, \Phi_1, \Phi_2, \ldots.., \Phi_M]$, which keeps only the distinguishing features for face images and removes the common features. Then eigenfaces are calculated by find the Covariance matrix C of the training image vectors by:

$$C = \frac{1}{M}\sum_{i=1}^{M} \Phi i\ \Phi i^T = A.A^T \quad (4)$$

Due to large dimension of matrix C, we consider matrix L of size (Mt X Mt) which gives the same effect with reduces dimension.

The eigenvectors of C (Matrix U) can be obtained by using the eigenvectors of L (Matrix V) as given by:

$$U_i = AV_i \quad (5)$$

The eigenfaces are:

$$\text{eigenface} = [U1,\ U2,\ U3, \ldots\ldots\ UM] \quad (6)$$

3.2 Discrete Cosine Transform (DCT)

DCT inherits many properties from Fourier transform and provides a wide range of applications such as image coding, data compression, feature extraction, multiframe detection, and filter banks. Discrete cosine transform (DCT) transform an image to frequency domain and perform quantization for data compression. The DCT is regarded as a discrete-time version of the Fourier-cosine series. Hence, it is considered as a Fourier-related transform similar to the Discrete Fourier Transform (DFT), using only real numbers. Since DCT is real-valued, it provides a better approximation of a signal with fewer coefficients, The Discrete Cosine Transform often called simply expresses a sequence of data points in terms of a sum of cosine functions oscillating at different frequencies. One of the advantages of the DCT has strong energy compaction properties [4]. Let $f(x, y)$ denote an image in spatial domain, and let $f(u, v)$ denote an image in frequency domain. The general equation for a 2D DCT is defined as [2]:

$$f(u,v) = C(u)\ C(v) \sum_{x=0}^{N-1} \sum_{y=0}^{N-1} f(x,y) \cos\left(\frac{(2x+1)u\pi}{2N}\right) \cos\left(\frac{(2y+1)v\pi}{2N}\right), \quad (7)$$

where if u=v=0,then C(u)=C(v)=$\sqrt{1/N}$; otherwise, C(u)=C(v)= $\sqrt{2/N}$. The inverse DCT can be represented as

$$f(x,y) = \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} C(u) C(v)\ f(u,v) \cos\left(\frac{(2x+1)u\pi}{2N}\right) \cos\left(\frac{(2y+1)v\pi}{2N}\right) \quad (8)$$

3.3. Discrete Wavelet Transform (DWT)

Discrete Wavelet Transform DWT [2] is multi-resolution de-compositions that can be used to analyze signals and images. It describes a signal by the power at each scale and position. DWT has been proved to be a very useful tool for image compression in the recent years. Wavelet transform exploits both the spatial and frequency correlation of data by dilations (or contractions) and translations of mother wavelet on the input data. It supports the multi resolution analysis of data i.e. it can be applied to different scales according to the details required, which allows progressive transmission and zooming of the image without the need of extra storage. Another encouraging feature of wavelet transform is its symmetric nature that is both the forward and the inverse transform has the same complexity, building fast compression and decompression routines.

In practice, it is not necessary to carry out all the possible decompositions until the size of 1*1 is reached. Usually, just a few levels are sufficient. Figure (4) shows three-level resolutions in a 2D wavelet transform, where Li , Vi, Hi, and Di denote the ith level sub images containing the low–low, high–low, low–high, and high–high passes, respectively. It shows the image decomposed in three levels. Each of the resulting sub images is known as a sub band [5]. Since the wavelet functions are compact, the wavelet coefficients only measure the variations around a small region of the data array. This property makes wavelet analysis very useful for signal or image processing. The localized nature of the wavelet transform allows one to easily pick out features such as spikes, objects, and edges. Wavelets are also extensively used for the purposes of filtration and preprocessing data, analysis and prediction of stock markets situations, image recognition, as well as for processing and synthesizing various signals, such as speech or medical signals, image compressing and processing [9,8].

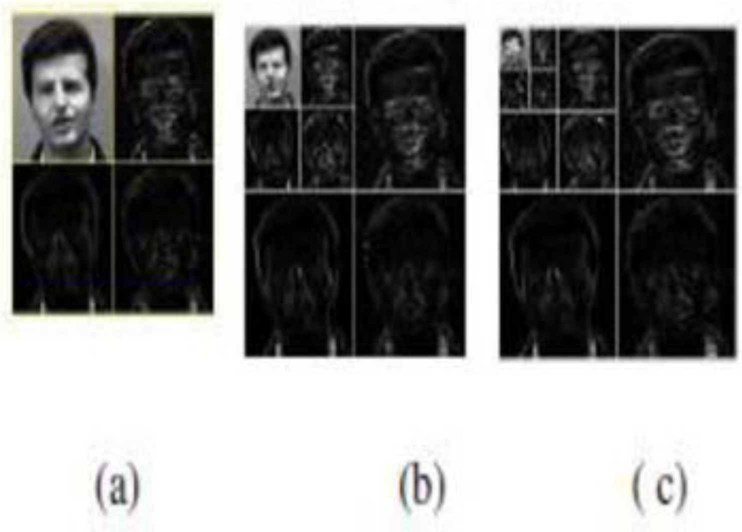

Figure 4. (a) DWT 1st level decomposition, (b) DWT 2nd level decomposition. (c) DWT 3rd level decomposition

4.Choose Model

In this stage the classification part is the identity of a face image from the database with the highest matching score, thus with the smallest differences compared to the input face image. In this paper the distance measures specially, Euclidean distance, Cosine and Correlation methods are used for face recognition. This paper discusses the comparison among these methods.

4.1. L2: Euclidean distance

The Euclidean distance is the straight-line distance between any two points *a* and *b* in the same plane. For point *a* at ($x1$, $y1$) and point *b* at ($x2$, $y2$), L2 distance is given as, $((x1 - x2)^2 + (y1 - y2)^2)$. For any two vectors $\boldsymbol{x}$ and $\boldsymbol{y}$ of length *n* each, Euclidean distance is given as

$$\boldsymbol{d}(\boldsymbol{x},\boldsymbol{y}) = \|\boldsymbol{x}-\boldsymbol{y}\|^2=\sum_{i=1}^{k}(\boldsymbol{x}_i\text{-}y_i)^2 \qquad (9)$$

4.2. Cosine distance

For any two given vectors x and y, the cosine distance between two given vectors is obtained by dividing the dot product of two given vectors by the product of the scalar value of the two vectors. Mathematically it is given as [3]

.

$$\mathbf{d}(\mathbf{x},\mathbf{y}) = -\frac{\mathbf{x}.\mathbf{y}}{\|\mathbf{x}\|.\|\mathbf{y}\|} = -\frac{\sum_{i=1}^{k}\mathbf{x}_i\,\mathbf{y}_i}{\sqrt{\sum_{i=1}^{k}\mathbf{x}_i^2\sum_{i=1}^{k}\mathbf{y}_i^2}} \qquad (10)$$

4.3. Correlation distance

One minus the sample correlation between points (treated as sequences of values).

$$d_{rs} = 1 - \frac{(x_r - \bar{x}_r)(x_s - \bar{x}_s)'}{[(x_r - \bar{x}_r)(x_r - \bar{x}_r)']^{1/2}\,[(x_s - \bar{x}_s)(x_s - \bar{x}_s)']^{1/2}} \quad (11)$$

5. The Experiments

The Experiments have done on the given data bases, to get the result; this work has built and written in Matlab9.0. In this work there are 7 experiments have been executed, two of them based on PCA method, one experiment based on DCT method, and four last experiments based on DWT method. The comparison is done for every method with the three recognition models (Euclidian distance, Cosine distance, and Correlation distance).

5.1. Face Recognition based on PCA method

For these experiments the train databases are loaded, then the features are extracted from the face images by applying PCA method and the recognized pattern vectors for each image are produced. The distance of eigenvector input test image from eigenvector of all the persons is found and the index of minimum distance during the recognition is identified the person, so the unknown face is classified.

5.1.1. Experiment (1): Recognition rate used ORL and Yale databases

This experiment is aimed to know what is the number of subjects that gives the best recognition percentage, therefore the classification is repeated every time depend on the number of subjects. The numbers of subjects are 10,15,20,25 and 30, and numbers of images for each person in the training set are five. The performance of PCA algorithm relating with various number of person is shown bellow. The recognition results on ORL dataset for PCA method using Euclidean distance, Correlation distance, and Cosine distance are given in the table (1).

Table (1). Recognition rate based on PCA method of ORL dataset.

Number of persons	Number of images	Recognition Rate %		
		PCA+ Euclidean distance	PCA+ Correlation	PCA+ Cosine
10	50	86%	100%	100%
15	**75**	**72%**	**97.33%**	**97.33%**
20	100	56%	88%	90%
25	125	61.6%	84.8%	85.6%
30	150	53.33%	83.33%	83.33%

Table (2). Recognition rate based on PCA method of Yale dataset.

Number of persons	Number of images	Recognition Rate %		
		PCA+ Euclidean distance	PCA+ Correlation	PCA+ Cosine
15	75	52%	74.67%	74.67%

The features extraction on Yale dataset based on PCA is done in a similar way as in case of ORL dataset. The number of persons in this experiment is taken as 15 due to the good result in previous experiment. Recognition results based on PCA method and using Euclidean distance, correlation distance, and cosine distance are given in the table (2).

5.1.2. Experiment (2): Number of images in the training database

In this experiment we aim to know the number of the images in the test set for a 10 persons that gives us the best recognition result. We have tried to recognize 10 persons with five images for each person in the test set, then the number of images in the test set is increased by one and the recognition is running again. The figure 5 shows that the selection of 6 images gives the best result from all images test. The percentage of it equal to 92.5%.

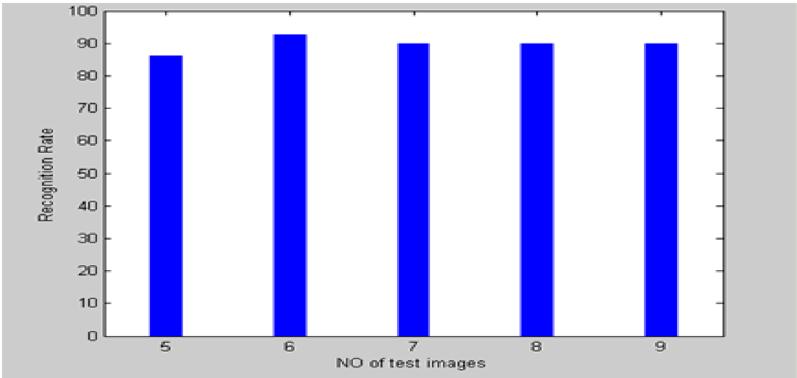

Figure 5. Recognition rate according to the number of images in the test set

5.2. Experiment (3): Face Recognition based on DCT method:

In this experiment the ORL train database is loaded. Then the features are extracted from the face images by applying DCT method. This experiment is similar to experiment 1.

The recognition results on ORL dataset for DCT method based on Euclidean distance, Correlation distance, and Cosine distance are given in the table (3).

Table (3). Recognition rate based DCT method of ORL dataset.

Number of persons	Number of images	Recognition Rate %		
		DCT + Euclidean distance	DCT + Correlation	DCT + Cosine
10	50	98%	94%	98%
15	75	96%	93.33%	96%
20	100	95%	90%	92%
25	125	92.8%	92%	92%
30	150	%91.33	%88.67	%90.67

Table (4). Recognition rate based on DCT method of Yale dataset.

Number of persons	Number of images	Recognition Rate %		
		DCT + Euclidean distance	DCT + Correlati on	DCT + Cosine
15	75	82.33%	85.33%	85.33%

The feature extraction on Yale dataset based on DCT is done in a similar way as in case of ORL dataset. Recognition results of using DCT method based on Euclidean distance, Correlation distance, and Cosine distance are given in the table (4).

5.3. Face Recognition based on DWT method

5.3.1. Experiment (4): Recognition rate based on DWT method using ORL and Yale datasets.

As the previous experiments, the recognition in this is experiment based on DWT method using Euclidean distance, Correlation distance, and Cosine distance. Recognition results on ORL dataset are given in the table (5).

Table (5). Recognition rate based DWT method of ORL dataset.

Number of subjects	Number of images	Recognition Rate %		
		DWT + Euclidean distance	DWT + Correlation	DWT + Cosine
10	50	98%	94%	98%
15	75	96%	93.33%	96%
20	100	95%	90%	92%
25	125	92.8%	91.2%	92%
30	150	91.33%	89.33%	90.67%

Table (6). Recognition rate based on DWT method of Yale dataset.

Number of subjects	Number of images	Recognition Rate %		
		DWT + Euclidean distance	DWT + Correlati on	DWT + Cosine
15	75	82.67%	80%	85.33%

94%	
96%	93.33%

The feature extraction on Yale dataset based on DWT is done in a similar way as in case of ORL dataset. Recognition results for DWT method using Euclidean distance, Correlation distance, and Cosine distance are given in the table (6).

5.3.2. Experiment (5): Recognition rate based on different levels of DWT method and Euclidean distance using ORL and Yale datasets.

This experiment used the different levels of DWT. The ORL dataset also used in this experiment. For recognition the experiment used Euclidean distance. In the experiment we have used different number of persons to the recognition. The table (7) shows the recognition results based on different levels of DWT and Euclidean distance using ORL dataset.

Table (7). Recognition rate ORL dataset based on different 3 levels DWT and Euclidean distance classifier

Number of subjects	Number of images	Recognition Rate % Euclidean distance classifier		
		DWT Level 1	***DWT Level 2***	***DWT Level 3***
10	50	%98	%98	%98
15	75	%96	%96	%97.33
20	100	%95	94.666	%96
25	125	%92.8	%93.6	%96.8
30	150	%91.33	%92.67	%95.33

Table (8). Recognition rate of Yale dataset based on different 3 levels DWT and Euclidean distance classifier

Number of subjects	Number of images	Recognition Rate % Euclidean distance classifier		
		DWT Level 1	***DWT Level 2***	***DWT Level 3***
15	75	%82.67	%81.33	%82.67

The feature extraction on Yale dataset based of different 3 levels DWT is done in a similar way as in case of ORL dataset. Recognition results are given in the table (8).

5.3.3. Experiment (6): Recognition rate based on different levels of DWT method and Correlation distance using ORL and Yale datasets.

In this experiment we aim to know what is number of persons that gives the best recognition percentage in wavelet transform for different 3 levels. Recognition results using ORL dataset and based on different 3 levels of DWT and Correlation distance classifier are shown in the table (9).

Table (9). Recognition rate ORL dataset based on different 3 levels DWT and Correlation distance classifier

Number of subjects	Number of images	Recognition Rate % Correlation distance classifier		
		DWT Level 1	***DWT Level 2***	***DWT Level 3***
10	50	%94	%96	%98
15	75	%93.33	%94.67	%97.33
20	100	%90	%96	%96
25	125	%91.20	%91.20	%94.40
30	150	%89.33	%89.33	%94

Table (10). Recognition rate Yale dataset based on different 3 levels DWT and Correlation distance classifier

Number of subjects	Number of images	Recognition Rate % Correlation distance classifier		
		DWT Level 1	***DWT Level 2***	***DWT Level 3***
15	75	%80	%80	%82.67

The feature extraction on Yale dataset based on different 3 levels of DWT is done in a similar way as in case of ORL dataset. Recognition results are shown in the table (10).

5.3.4. Experiment (7): Recognition rate based on different levels of DWT method and Cosine distance using ORL and Yale datasets.

The DWT method and the three level of this method with Cosine distance classifier is used in this experiment. The dataset ORL for training are used in this experiment also. Recognition results are shown in the table (11).

Table (11). Recognition rate of ORL dataset based on different 3 levels DWT and Cosine distance classifier

Number of subjects	Number of images	Recognition Rate % Cosine distance classifier		
		DWT Level 1	***DWT Level 2***	***DWT Level 3***
10	50	%98	%98	%98
15	75	%96	%96	%97.33
20	100	%92	%93	%96
25	125	%92	%92.80	%95.20
30	150	%90.67	%91.33	%94.67

Table (12). Recognition rate of Yale dataset based on different 3 levels DWT and Cosine distance classifier

Number of subjects	Number of images	Recognition Rate % Cosine distance classifier		
		DWT Level 1	***DWT Level 2***	***DWT Level 3***
15	75	%85.33	%85.33	%86.33

The feature extraction on Yale dataset based on different 3 levels of DWT is done in a similar way as in case of ORL dataset, Recognition results are given in table (12).

6. Results and Discussions

The tables (1 and 2) show that the PCA method with Correlation and Cosine distance give good result with 15 persons and 75 images. Also in the table (3) the recognition rate is enhanced by using DCT method with Euclidean and Cosine distance, but in the table (4) the DCT method with Cosine distance gives better result.

The performance evaluation of proposed algorithm of DWT with difference classifiers on ORL databases is given in table (5), The (DWT + Euclidean distance) and (DWT + cosine) show better performance in small size of database 10 subjects with 50 test images achieves up 98%. We found higher recognition rate of the proposed algorithm (DWT + Euclidean distance) on 150 test images of 30 different subjects achieves up 91.33%, the algorithm (DWT+ Correlation) its recognition accuracy achieves up 89.33%, and the algorithm (DWT + cosine) its recognition accuracy achieves up 90.67%, we found no large difference of recognition rate based on DWT method with the three metrics (Euclidean distance, Correlation, and cosine). Hence the recognition rate is more when compared with PCA method, and close to the DCT method.

The wavelet transform is sensitive to strong lighting conditions, but can recognize different facial expressions (open/closed eyes, smiling/non-smiling) and facial details (glasses/no-glasses, head orientations), because discrete wavelet transform at different scales and orientations are used on images. The tables (7, 8 ,9 10, 11, and 12) show that the DWT with level 3 give good result than other levels and the recognition rate using Euclidean distance classifier is increased when the level of DWT is increased also.

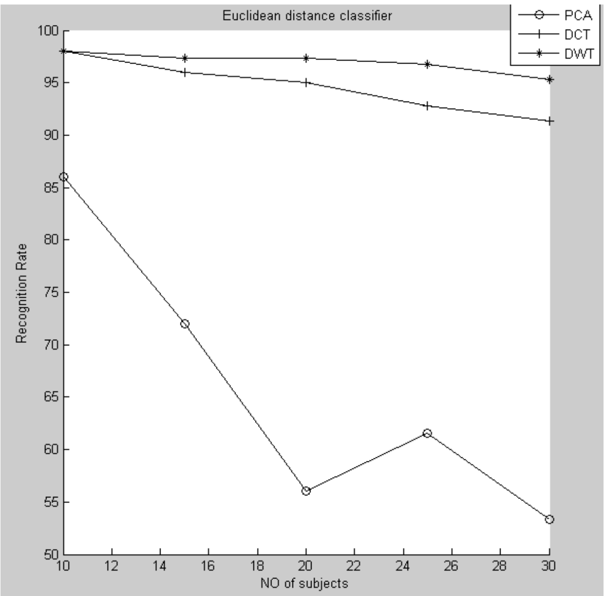

Figure 6. Recognition rate for ORL database based PCA, DCT, DWT with Euclidean Distance

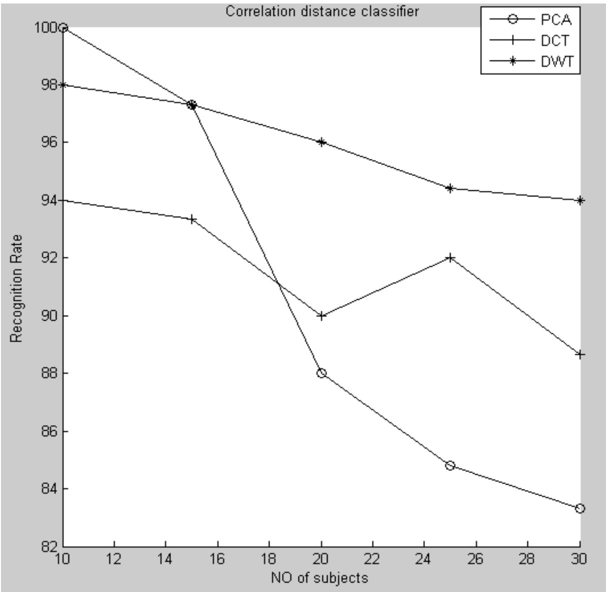

Figure 7. Recognition rate for ORL database based PCA, DCT, DWT with Correlation Distance

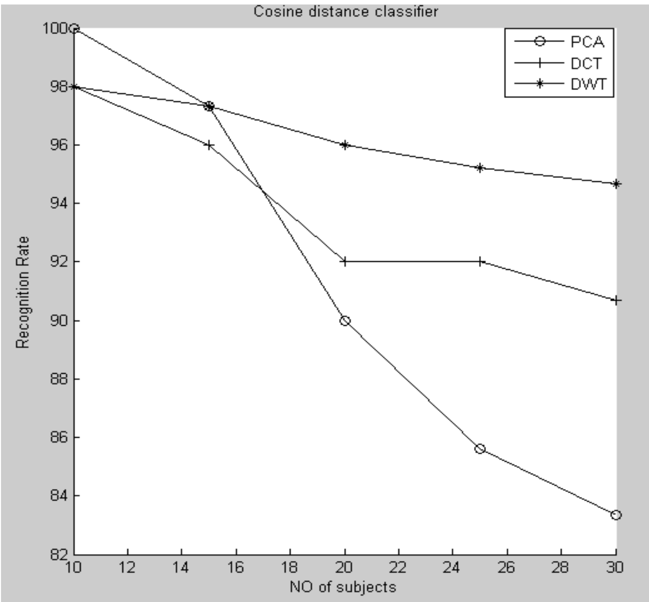

Figure 8. Recognition rate for ORL database based PCA, DCT, DWT with Cosine Distance

The Yale face database includes both lighting and expression changes. The performance evaluation of methods PCA, DCT, and DWT with difference classifiers on Yale database doesn't give good result than the ORL data base. We find that the DWT and DCT methods with Euclidean Distance and Cosine distance classifiers have similar results and better than the correlation distance classifier. The PCA method works better with the correlation and cosine classifiers than the Euclidean Distance, also we find the almost of misclassified images have big shadow causing the difference light, so our methods are not good working with lighting changes.

Figure (6, 7 and 8) show the three recognition classifiers (distance measures) using the ORL and Yale database with the Principal Component Analysis (PCA), Discrete Cosine Transform (DCT), and Discrete Wavelet Transform (DWT). The recognized users are increased as shown in the figures. From the figures, it is clear that the PCA gives the better results with Cosine distance and Correlation distance with the persons less than 15 and when the number of persons is increasing, the recognition rate is decreasing quickly. So this model of recognition is useful for identification closing set. On the other side DWT on 3rd level decomposition gives the better results with Euclidean Distance (above 95.33% recognition rate), and it is stable with recognition when the persons are increased, especially with Cosine and Correlation distance. The DCT method similar to DWT, but it is less value of recognition rate than DWT.

7. Conclusion

This paper presented a comparison of using three methods (PCA, DCT, and DWT) of extraction features with three method of classification (Euclidean distance, Cosine distance and Correlation distance). The recognition rate is enhanced much more when applying recognition classifiers (distance measures) on the ORL than Yale database. For the persons less than 15, the PCA gives the better results with Cosine distance and Correlation distance, but the DWT 3rd level decomposition method is the best method with the Euclidean Distance (above 95.33% recognition rate). The DCT method similar to DWT, but it is less value of recognition rate than DWT. The overall results show that the using the DWT method is useful for recognition.

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التعرف على الوجوه القائم على مبدأ تحليل المكونات PCA ، تحويل جيب التمام المتقطع DCT ، تحويل ووفلت المتقطع DWT ومقاييس المسافة

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الملخص

يعتبر التعرف على الوجة واحد من مجالات البحث المهمة نظرا لتطبيقاتها المختلفة مثل التعرف على الهوية ، الامن والتحكم والتفاعل بين الانسان والحاسوب0 في هذة الورقة ثم استخدام عدة خوارزميات لاستخراج المميزات الاساسية مثل طريقة تحليل المكونات الرئيسي PCA وتحويل جيب التمام المتقطع DCT وتحويل ووفلت المتقطع DWT وثم كذلك استخدام انواع مختلفة من مقاييس المسافة للتعرف على الوجة مثل المسافة الاقليدية ومسافة جيب التمام ومسافة الارتباط 0 وقد تم اختبار هذة الطرق على قاعدتي البيانات ORL و Yale للتعرف على الوجوة0

النتائج الاختبارية المطبقة على قاعدة البيانات ORL اعطت نتائج جيدة0 وفي هذة الورقة البحثية وجدنا ان طريقة DWT المستوى الثالث هي افضل طريقة للتعرف على الوجوة مع المسافة الاقليدية (95033%) من بقية الطرق، اما طريقة PCA فقد اعطت نتيجة جيدة مع مسافة جيب التمام ومسافة الارتباط 0 وتظهر النتائج الاجمالية ان استخدام طريقة DWT هي مفيدة للتعرف 0

الكلمات المفتاحية: *التعرف على الوجة ، PCA ، DCT ، DWT ، قياسات المسافة*