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# A Face Recognition Scheme Based On Principle Component Analysis and Wavelet Decomposition

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***Abstract***: *In this paper, a new face recognition system based on Wavelet transform (HWT) and Principal Component Analysis (PCA) is presented. The image face is preprocessed and detected. The Haar wavelet is used to form the coefficient matrix for the detected face. The image feature vector is obtained by computing PCA for the coefficient matrix of DWT. A comparison between the proposed recognition system using DWT, PCA and Discrete Cosine Transform (DCT) is also made.*
***Keywords****: Wavelet Transform, Principal Component Analysis.*

## I. INTRODUCTION

Face recognition is one of most successful applications in computer vision and pattern recognition and the main objective of it is to recognize persons from pictures or video using a stored database of faces [1]. The building of face recognition system is a sophisticated problem because the faces has a lot of variations and may be located in a changed environment. Because of these reasons, the recognition of faces is a challenging problem due to the wide variety of illumination, facial expression and pose variations. In developing a face recognition system, we have to select suitable properties to represent a face under environmental changes. Face recognition is used in many applications such as human computer interaction, biometrics and security system [2].

In the recent years, wavelet analysis have generated a great interest in both theoretical and applied mathematics, and the wavelet transform in particular has proven to be an effective tool for e.g. data analysis, numerical analysis, and image processing [3].

The face recognition methods are categorized into holistic matching methods, feature-based matching methods, and hybrid methods [4]. Holistic matching methods use the whole face region as the raw input to a recognition system. It is reported in [4] that one of the methods used in representations of the face region is Eigen faces, which are based on Principal Component Analysis (PCA). Using PCA, many face recognition techniques have been developed: Eigen faces, which use a nearest neighbor classifier; feature-line-based methods, which replace the point-to-point distance with the distance between a point and the feature line linking two stored sample points; Fisher faces which use linear/Fisher discriminant analysis (FLD/LDA); Bayesian methods, which use a probabilistic distance metric; and SVM methods, which use a support vector machine as the classifier. Utilizing higher order statistics, independent-component analysis (ICA) is argued to have more representative power than PCA, and hence may provide better recognition performance than PCA [4]. For the other types of recognition, it can be referred to reference [4].

It is reported in [5] that dimension reduction is as important as the class separation in applications like face recognition to make the face recognition system model based on the discrete cosine transform (DCT) computationally efficient. DCT helps to separate the image into parts (or spectral sub-bands) of differing importance (with respect to the image's visual quality). The DCT is similar to the discrete Fourier transform: it transforms a signal or image from the spatial domain to the frequency domain and represents an image as a sum of sinusoids of varying magnitude and frequencies. In proposed model [5] of face recognition dimension reduction is achieved firstly through decimation algorithm and then DCT is applied which exhibits large variance distribution in a small number of coefficients and much of the signal energy lies in low frequencies; these appear in the upper left corner of the DCT [5].

## II. WAVELET TRANSFORM

In numerical analysis and functional analysis, a discrete wavelet transform (DWT) is any wavelet transform for which the wavelets are discretely sampled. As with other wavelet transforms, a key advantage it has over Fourier transforms is temporal resolution: it captures both frequency and location information. The first DWT was invented by the Hungarian mathematician Alfréd Haar. For an input represented by a list of $2^n$ numbers, the Haar wavelet transform may be considered to simply pair up input values, storing the difference and passing the sum. This process is repeated recursively, pairing up the sums to provide the next scale: finally resulting in $2^n - 1$ differences and one final sum.

Wavelets are functions that satisfy certain mathematical requirements and are used in representing data or other functions. This idea is not new. Approximation using superposition of functions has existed since the early 1800's, when Joseph Fourier discovered that he could superpose sines and cosines to represent other functions. However, in wavelet analysis, the scale that we use to look at data plays a special role. Wavelet algorithms process data at different scales or resolutions. If we look at a signal with a large "window", we would notice gross features. Similarly, if we look at a signal with a small "window", we would notice small features. The result in wavelet analysis is to see both the forest and the trees, so to speak [6].
Using the classical wavelet decomposition, the image is decomposed into the approximation and details images, the approximation is then decomposed itself into a secondlevel of approximation and details and so on (Press, 1992). Wavelet Packet Decomposition (WPD) is a generalization of the classical wavelet decomposition and using WPD we decompose both approximations and details into a further level of approximations and details. Theoretical backgrounds of the wavelet transform could be found in (Daubechies, 1992; Strichartz, 1994), comprehensive description of the computerised realisation and source code could be found in (Press, 1992). We will present only the main ideas related to the practical implementation..

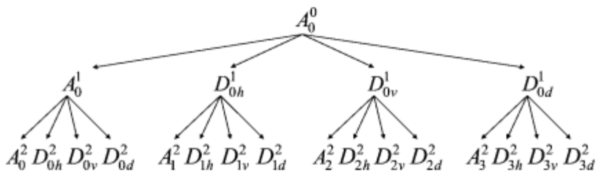


Fig. 1 Wavelet Tree Decomposition

## III. PRINCIPLE COMPONENT ANALYSIS

The Principal Component Analysis (PCA) is one of the most successful techniques that have been used in image recognition and compression. PCA is a statistical method under the broad title of factor analysis. The purpose of PCA is to reduce the large dimensionality of the data space (observed variables) to the smaller intrinsic dimensionality of feature space (independent variables), which are needed to describe the data economically. This is the case when there is a strong correlation between observed variables.
The jobs which PCA can do are prediction, redundancy removal, feature extraction, data compression, etc. Because PCA is a classical technique which can do something in the linear domain, applications having linear models are suitable, such as signal processing, image processing, system and control theory, communications, etc. Face recognition has many applicable areas. Moreover, it can be categorized into face identification, face classification, or sex determination. The most useful applications contain crowd surveillance, video content indexing, personal identification (ex. driver's licence), mug shots matching, entrance security, etc. The main idea of using PCA for face recognition is to express the large 1-D vector of pixels constructed from 2-D facial image into the compact principal components of the feature space. This can be called eigen-space projection. Eigen-space is calculated by identifying the eigenvectors of the covariance matrix derived from a set of facial images(vectors).

A 2-D facial image can be represented as 1-D vector by concatenating each row (or column) into a long thin vector. Let's suppose we have M vectors of size N (= rows of image × columns of image) representing a set of sampled images. p j 's represent the pixel values

$$x_i = [p_1 . . . p_N]^T, \ i = 1........M$$

The images are mean centered by subtracting the mean image from each image vector. Let m represent the mean image.

$$m = 1/M \sum_{i=1}^{M} x_i$$

The eigenvectors corresponding to nonzero eigenvalues of the covariance matrix produce an orthonormal basis for the subspace within which most image data can be represented with a small amount of error. The eigenvectors are sorted from high to low according to their corresponding eigenvalues. The eigenvector associated with the largest eigenvalue is one that reflects the greatest variance in the image. That is, the smallest eigenvalue is associated with the eigenvector that finds the least variance. They decrease in exponential fashion, meaning that the roughly 90% of the total variance is contained in the first 5% to 10% of the dimensions [7].

Once the eigen faces have been computed, several types of decision can be made depending on the application. What we call face recognition is a broad term which may be further specified to one of following tasks:

- Identification where the labels of individuals must be obtained,
- Recognition of a person, where it must be decided if the individual has already been seen,
- Categorization where the face must be assigned to a certain class.

PCA computes the basis of a space which is represented by its training vectors. These basis vectors, actually eigenvectors, computed by PCA are in the direction of the largest variance of the training vectors. As it has been said earlier, we call them eigen faces. Each eigen face can be viewed a feature. When a particular face is projected onto the face space, its vector into the face space describe the importance of each of those features in the face. The face is expressed in the face space by its eigenface coefficients (or weights). We can handle a large input vector, facial image, only by taking its small weight vector in the face space. This means that we can reconstruct the original face with some error, since the dimensionality of the image space is much larger than that of face space.

## IV. METHODOLOGY ADOPTED

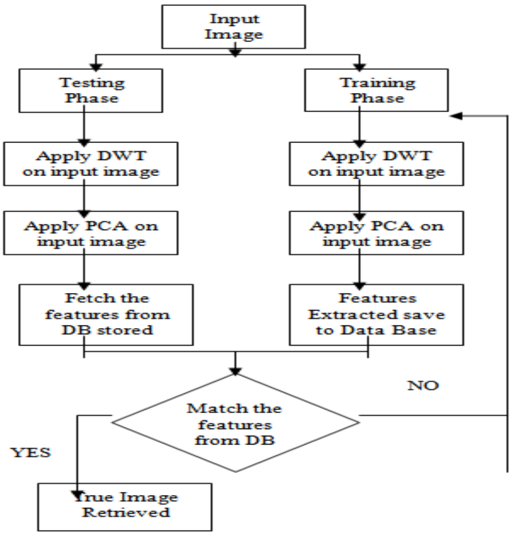


Fig. 2 Flow Chart of the Methodology Adopted

## V. RESULT AND DISCUSSION

Fig 3. Generated during the execution of the code for following method, the given image is a snapshot which shows us the first step to select the training database path.

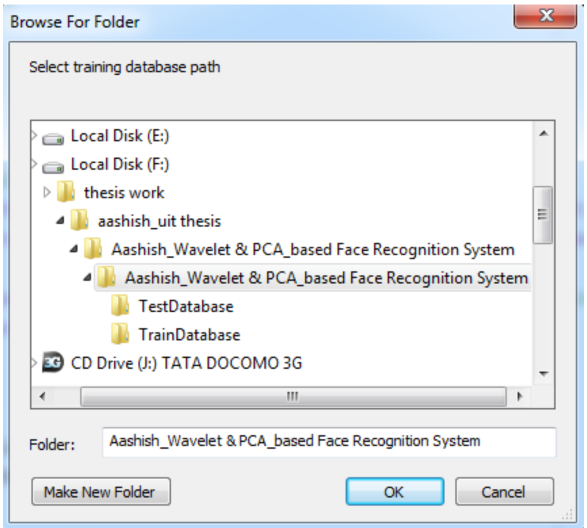


Fig 3. GUI of selecting Training DataBase

Fig 4. is generated during the second step, that is after selecting the training path, it popup a window to select the test database path.

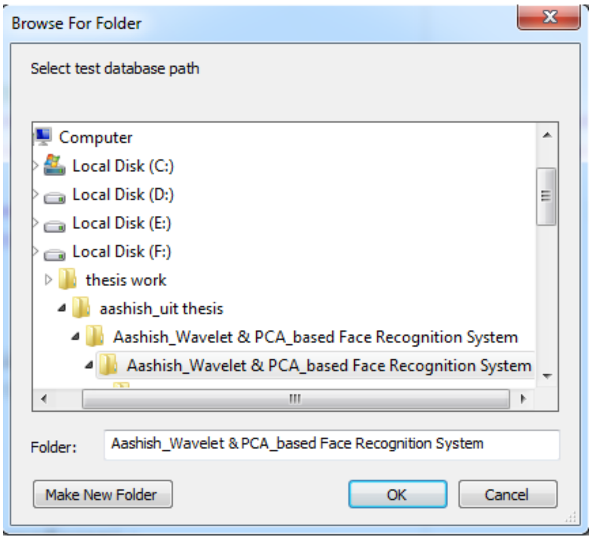


Fig. 4 GUI of selecting Testing DataBase

In the database images has been saved by numbers 1,2,3 etc. so fig 5 is the snapshot which ask the user to select the particular number of image for which user want to perform face recognition. The given fig shows that user selected image number 5.

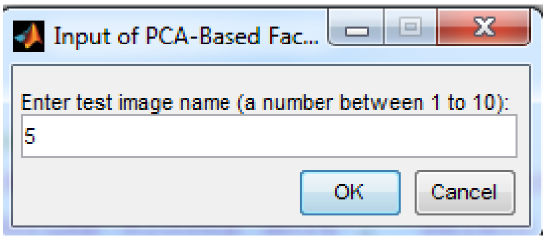


Fig. 5 Selecting a Test Image

Fig.6 shows the test image according to the number given by the user.

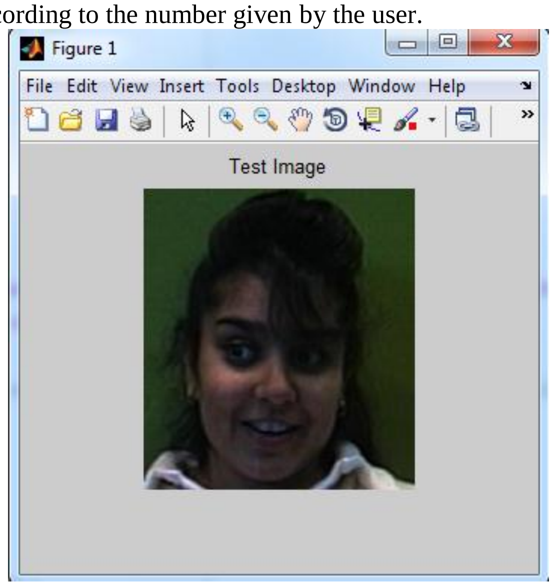


Fig. 6 Test Image

In the Fig.7 the equivalent image matched with the test image selected by the user is showed.

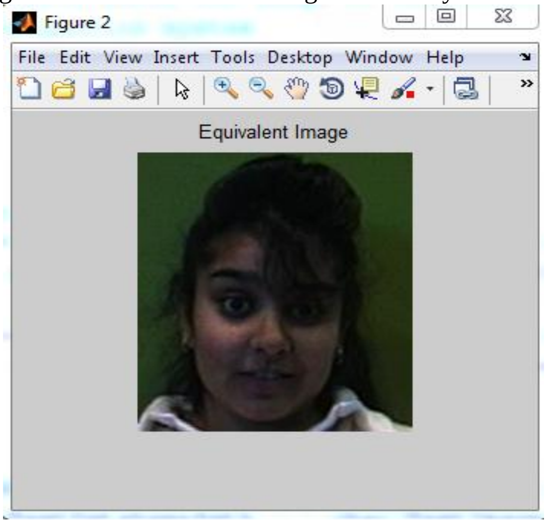


Fig .7 Equivalent Image

150 face images of 50 person have been taken for the performance analysis of algorithm developed, each image is different from the images of same person in terms of the face expression, few of them has been shown here below.

Fig.8 database of test images

## VI. CONCLUSION

The proposed face recognition system based on wavelet and PCA has been introduced and evaluated. The simulation work has been carried out on MATLAB 7.8.1. The result of the method adopted found to be better than the previous one.

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