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FACE RECOGNITION USING FEATURE EXTRACTION TECHNIQUE

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ABSTRACT:
Face Recognition is a type of biometric software application. It is an active and alive research field spread over the several areas, machine learning, image analysis, image processing, pattern matching-recognition and neural networks. It is hand-free and non-intrusive method of identifying individual human faces by the feature extraction technique and classification of faces. Feature extraction is one of the most important researches in computer vision. This paper compares the different feature extraction approaches such as Gabor Filter, Singular Value Decomposition (SVD), Discrete Cosine Transform, Discrete Wavelet Transform, and Dimensional Reduction techniques such as eigen-face approach (PCA), fisher-face approach (LDA) are used to extract the useful features for human face recognition. The main focus of this paper is to improve the robustness of Automatic Face Recognition Systems.

Keywords :- Face recognition, Feature extraction. Gabor Filter, DCT, SVD, PCA, LDA.

INTRODUCTION :

A biometric system is a pattern recognition system that operates by acquiring biometric data from an individual, extracting a feature set from the acquired data, and comparing this feature set against the template set in the database. When the first time user uses a biometric system called as enrolment. During this, biometric information from an individual is captured and stored in the database. Then biometric information is detected and compared with the stored information at the time of enrolment. The sensor is the interface between the real world and the system. Any biometric system[1] includes two different modes: verification mode and identification mode.

FACE RECOGNITION

Face is one of the most acceptable biometrics because of most common method of identification which use in their visual interaction. There are two primary approaches to the identification based on face recognition. The first approach is Transform approach [2-3] and the most popular vectors are eigenfaces. Each eigenface is derived from covariance analysis of face image, two faces are considered to be identical if they are nearly close in eigenface feature space. Another approach is Attribute-based [4]. The facial attributes like eyes, eyebrows, nose, mouth, shape of the face, shape of the mouth, etc are extracted from the face images for the identity of a person. The invariance of geometric properties among the face features is used for recognizing the face.

The main advantages of face biometrics is that this method is hands-free and non-intrusive (identification can continuously be performed from a distance). It has high accuracy in recognition in environment and highly approved by the majority of users. Face recognition is an active and live research area as face verification is used in applications like face tracking, CCTV,

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criminal detection, forensic evidence etc. to enable this biometric technology we require a PC camera or video camera. As mentioned by Anil K. Jain et al., the two most popular recognition approaches are [1]:

- Measuring the location and shape of facial attributes (e.g. distances between pupils or from nose to lip or chin);
- Analyzing the overall face image as "a weighted combination of a number of canonical faces".

Detecting faces in a given image and recognizing persons based on their face images are classical object recognition problem that have received extensive attention. Because of advances in information technology and demand for high security and surveillance, human face recognition is one of the most important biometrics. This work is motivated to develop a feature extraction technique for recognising human face.

FEATURE EXTRACTION TECHNIQUES

Face recognition commonly includes feature extraction, feature reduction and recognition or classification. Many researchers have tried to develop various feature extraction[5-8] techniques for human face recognition. They specify various existing techniques of feature extraction for human face recognition process. Feature extraction is to find the most representative description of the faces, making them can be most easily distinguished from others.

The usage of a mixture of techniques makes it difficult to classify these systems based purely on what types of techniques they use for feature representation or classification [5]. Recognition or classification is to choose the best available measure method such as Euclidean distance, which is used to classify the feature of face images present in the database and test image. Features may be symbolic, numerical or both. The various feature extraction techniques for human face recognition are divided into Geometric and Photometric approaches. Geometric approaches consider individual features such as eyes, nose, mouth and a shape of the head and then develop a face model based on the size and the position of these characteristics. In photometric approaches the statistical values are extracted, subsequently, these values are compared with the related templates.

Gabor Filter:

The Gabor filter [9-13] is an image processing tool which is applied for feature extraction that stores the information about the digital images [9]. Gabor functions first proposed by Dennis Gabor as a tool for signal detection in noise. Denis Gabor [10] showed that there exists a "quantum principle" for information. The time-frequency domain for 1D signal must necessarily be quantized so that no signal or filter can occupy less than certain minimal area in it. A large number of researches have been devoted to feature extraction based on Gabor filter [11-12,14].

The characteristics of Gabor wavelets are quite similar to those of human visual system for frequency and orientation representations. This Gabor-wavelet based extraction of features directly from the gray-level images is successful and widely been applied to texture segmentation and fingerprint recognition. Gabor Wavelet filter works as a band pass filter for the local spatial frequency distribution, achieving an optimal resolution in both spatial and frequency domains.

A face image is convolved with Gabor filter of five spatial frequencies and eight orientations, The Gabor filters with the different frequencies and orientations, which form the Gabor filter bank, have been used to extract features of face images. Following figure shows a family of Gabor wavelets on ORL face image.

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Singular Value Decomposition:

The basic idea behind SVD[17] is taking high variable set of data points and reducing it to a lower dimension set that better exposes the substructure of the original data more clearly by ordering the lower dimensional data from most variance to the least. It is a powerful linear algebra technique for solving linear-equations in the least-square sense, and works even for singular matrices or matrices numerically close to singular.

The SVD are known to be more robust than usual eigen vectors of covariance matrix. This is because, the robustness are determined by the directional vectors rather than mere scalar quantity like magnitudes (Singular value stored in S). SVD can be used to find a solution of a set of linear equations corresponding to a singular matrix that has no exact solution it locates the closest possible solution in a least-square sense [18]. The advantage of SVD over eigen decomposition that for a prescribed accuracy of computation SVD requires half the numerical precision of eigen decomposition [19].

Discrete Cosine Transform:

The Discrete Cosine Transform (DCT) [20-21] captures both frequency and location information (location in time). DCT is similar to the Discrete Fourier Transform (DFT) in the sense that they transform a signal or image from the spatial domain to the frequency domain, use sinusoidal base functions, and exhibit good de-correlation and energy compaction characteristics. Discrete Cosine Transform (DCT) of an N*M image has used for feature extraction. In this matrix high frequency components are located at the top left corner of the matrix and the low frequency components are located at the bottom right corner of the matrix. The selection static coefficient selection approach is used for the coefficient. In this approach the most prominent coefficients are selected from a DC coefficient [19,20,22] using zigzag manner diagonally as Figure 5.

Above figure 5 shows two components AC (Alternate Current) and DC (Direct Current) [23]. The AC components represent individual pixel value while DC component represents the whole image. Discrete Cosine Transform has the properties of decorrelation, energy compaction, orthogonality and separability. The advantages of DCT [20] feature extraction is a better job of concentrating energy in to lower order coefficients. The disadvantage of the DCT feature extraction technique is that the DCT features are sensitive to changes in the illumination direction. Only spatial co-relation of pixel inside the single 2D-block is considered and co-relation from pixel of neighboring block is neglected and the magnitude of the DCT coefficients is not spatially invariant. The output array of Discrete Coefficient Transform coefficients contains integers. DCT is easier to implement computationally and also efficient to consider a set of basic functions which given a known input array size 8×8 [24].

Principal Component Analysis:

Principal Component Analysis (PCA) [25-31] is a dimensionality reduction technique that is used for image recognition and compression. This reduction in dimensions removes information that is not useful and precisely decomposes the face structure into orthogonal (uncorrelated) components known as Eigen faces. In PCA, Eigenfaces recognition derives its name from the German prefix 'eigen', meaning 'own' or 'individual'. The basic idea of using the eigenfaces was first proposed by Kirby and Sirovich [26] using Karhunen-Loeve(KL) transform to represent human faces. This approach was very successful in representing faces using the above mentioned analysis. It is also known as Karhunen-Loeve transformation (KLT) or eigenspace projection [25-26]. In this method, faces are represented by a linear

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combination of weighted eigenvector, known as eigenfaces. PCA can be applied to the task of face recognition by converting the pixels of an image into a number of eigenface feature vectors, which can then be compared to measure the similarity of two face images.

The PCA algorithm is as follows:

1. Acquire an initial set of face images (the training set and testing set) and form its feature vector representation.
2. Calculate the covariance matrix.
3. Form the Eigen-faces according to the highest Eigen value of the covariance matrix.
4. Classify the given face image, according to the Euclidean distance and threshold values.

Linear Discriminant Analysis (LDA):

Linear Discriminant Analysis (LDA) [32-35] is a powerful face recognition technique that overcomes the limitation of Principal Component Analysis technique by applying the linear discriminant criterion. LDA is a dimensionality reduction technique which is used only for classification problem not for regression. The main aim is to find the linear combinations of the data that maximize the ***between-class*** variability while minimizing the ***within-class*** variability. This means it tries to find a new reduced subspace that provides the best separation between the different classes in the input data. Each face image is considered in higher dimensional space. After applying LDA to the data to get new vectors called as Fisher faces. The face image is then projected from two dimensional spaces to C dimensional space, where C is the number of classes of the images. The LDA method tries to find the subspace that discriminates different face classes.

The LDA algorithm is applied to all face images as below:

1. Acquire the training set and test set of face images and form its feature vector representation.
2. Calculate the within class and between-class covariance matrices S_W and S_B matrices.
3. Classify the given face image, according to the Euclidean distance and threshold values.

Discrete Wavelet Transform (DWT):

Discrete Wavelet Transform (DWT) [36] is used in image and signal analysis. It decomposes an image into a set of basic functions called wavelets and the decomposition is defined as the resolution of an image. Wavelets are functions that satisfy certain mathematical requirements and are used in presenting data or other functions, similar to sine and cosine in the Fourier transform. However, it represents data at different scales or resolutions, which distinguishes it from the Fourier transform. Two-dimensional DWT is implemented as a set of filter banks, comprising of a cascaded scheme of high-pass and low-pass filters. 2D-DWT decomposes an image into 4 “sub-bands” that are localized in frequency and orientation, by LL, HL, LH, HH [37].

Discrete Wavelet Transform (DWT) [38-40] is obtained by filtering the signal through a series of digital filters at different scales. The scaling operation is done by changing the resolution of the signal by the process of subsampling. In DWT, the input sequence is decomposed into low-pass and high-pass sub-bands, each consisting of half the number of samples in the original sequence. The band LL is a closer approximation to the original image. The bands LH and HL record the changes of the image along horizontal and vertical directions, respectively. The HH band shows the high frequency component of the image. Second level decomposition can then be conducted on the LL sub band. The various wavelet transforms like Daubechies wavelets, Coiflets, Biorthogonal wavelets, and Symlets are different in mathematical properties such as symmetry, number of vanishing moments and orthogonality.

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Classification Technique:

After extracting the face features, the next step is to classify the face image using classification [41]. Classification techniques [42-44] such as supervised or unsupervised learning will then be selected on the basis of the training data sets. Various classification techniques will be compared with the training data, so that an appropriate decision rule is selected for subsequent classification. The classified results should be checked and verified for the recognition accuracy and reliability.

Appearance-based face recognition algorithms use a wide variety of classification methods. Sometimes two or more classifiers are combined to achieve better results. According to Jain, Duin and Mao [43], there are three concepts that are the key in building a classifier - similarity, probability and decision boundaries.

The goal of achieving correct classification rate according to the characteristics required has been always desired. Feature extraction greatly affects the design, development and performance of the classifier, and it is one of the core issues of face recognition research.

CONCLUSION:

As an important component of pattern recognition, feature extraction has been paid close attention by many scholars, and currently has become one of the research hot spots in the field of pattern recognition. This paper deals with feature extraction techniques for human face recognition. We have presented different approaches to automatic face recognition using concepts of different feature extraction techniques with classifications. The main focus was to improve the robustness of Automatic Face Recognition Systems taking into consideration different variations of face images of each individual.

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Table 1: Similarity based Classifiers

Method	Description
Template Matching	Assign sample to most similar template
Nearest Mean	Assign pattern to nearest class mean
1-Nearest Neighbor (1-NN)	Assign pattern to nearest pattern's class
k-Nearest Neighbor (k-NN)	Like 1-NN, but assign to the majority of k-nearest pattern
Subspace Method	Assign pattern to nearest class subspace

Table 2: Probability based Classifiers

Method	Description
Neural Network Classifier	Classifier which maps any input pattern to a number of classifications.
Bayes Classifier	Assign pattern to the class with the highest estimated posterior probability
Logistic Classifier	Predicates probability using logistic curve method
Parzen Classifier	Bayesian classifier with Parzen density estimates

Table 3: Decision boundary based Classifiers

Method	Description
Minimum Distance Classifier	Identity covariance matrix. Euclidean distance
Fisher Linear Discriminant (FLD)	Linear classifier. Can use MSE optimization.
Binary Decision Tree (BDT)	Nodes are features. Can use FLD.
Perceptron	Iterative optimization of a classifier (e.g. FLD)
Multi-layer Perceptron	Two or more layers. Uses sigmoid transfer functions.
Radial Basis Network (RBN)	Optimization of a Multi-layer perceptron. One layer at least uses Gaussian transfer functions.
Support Vector Machines (SVM)	Maximizes margin between two classes.

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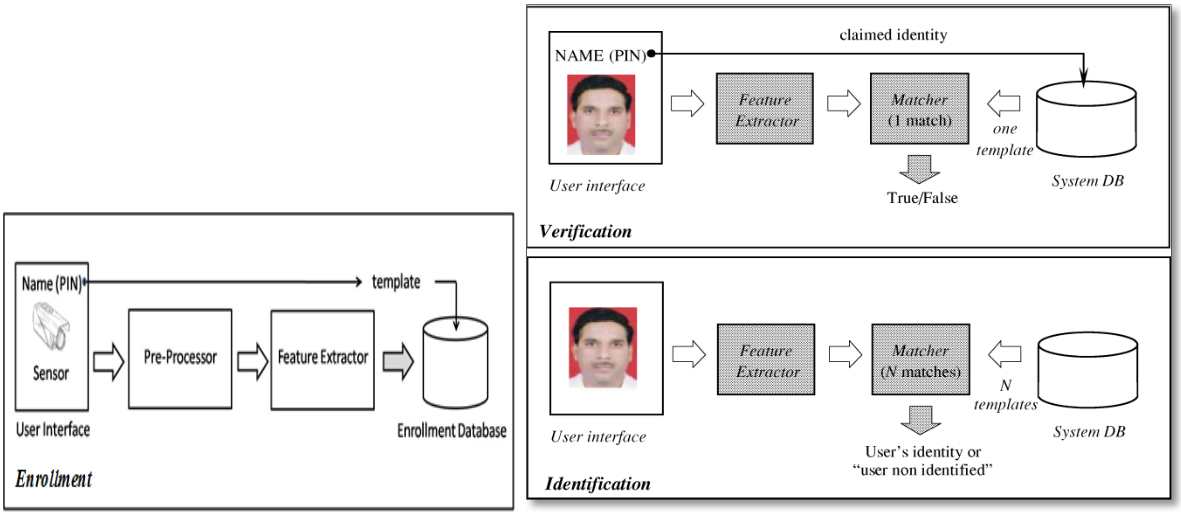
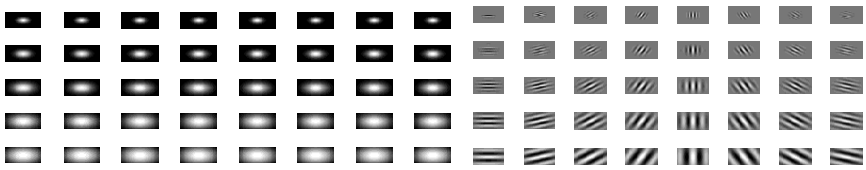


Fig. 1: Block diagram of a biometric system [1].



(a) (b)

Fig. 2: (a) Magnitude of Gabor Filter, and (b) Real part of Gabor Filter with 5 different scales and 8 different orientations

Fig. 3 Original face image from ORL database

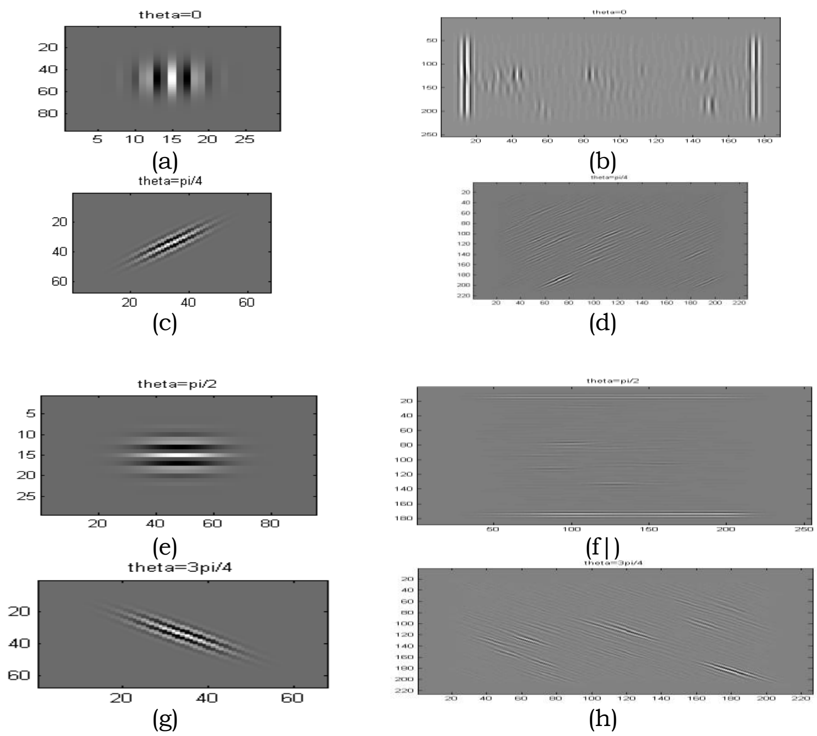


Fig.4: Gabor Wavelets (a), (c), (e), (g) and its filters (b), (d), (f), (h) on different values of theta (θ=0, π/4, π/2, 3π/4) from figure 3 [15-16]

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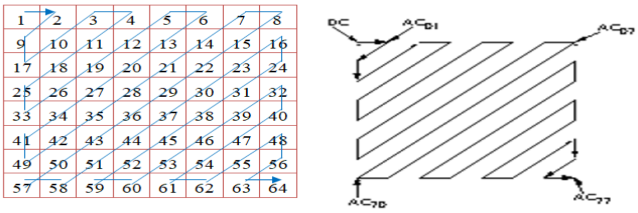
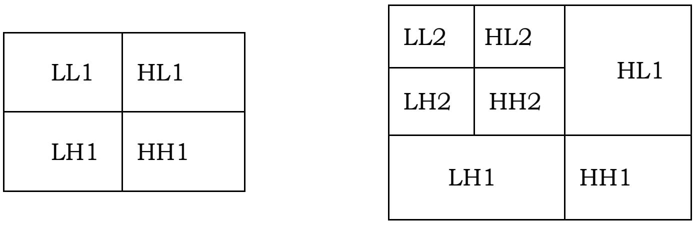


Fig. 5: Zigzag Scanning of DCT coefficients of 8x8 pixel image for Feature Vector



(a) (b)

Fig.6: Discrete Wavelet Transform: a) 1-D DWT b) 2 level 2-D DWT

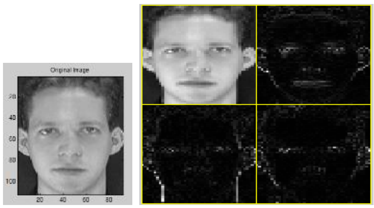


Fig. 7: Original face image from ORL and its 2D-Decomposition at level 1

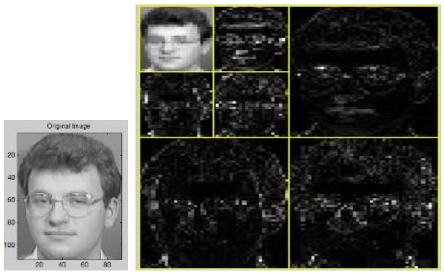


Fig. 8: Original face image from ORL and its 2D-Decomposition at level 2

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