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Face Recognition using Principal Component Analysis and ANN

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Abstract: Human Face detection is the process of identifying the features of faces to detect the faces on the basis of the discriminant features. Features of faces are eyes, ears, eyebrows, nose, lips, hairs, chicks, forehead etc. Face detection can be carried out using these features of faces. Face is important part to identify the person. It can be used as the computer visual application. Face is the important part of our body by which it is easy to identify and recognize the person. Face detection is one of the challenging tasks as there are many issues such as changes in the appearances of faces, variations in poses, noise, distortion and illumination condition. In this paper, the framework for efficient face detection using fusion of PCA and Artificial neural network is presented. The image features are represented as reduced features space by using PCA which is a dimensionality reduction technique. Further these features are given as input to the ANN for training. Multilayer perceptron network is used here for accomplishing this task.

Keywords: PCA, Eigen faces, Eigen space, Face Detection, Face recognition, ANN.

I.INTRODUCTION

Biometric is derived from a Greek word "bio"meaning life and metrics meaning "to measure". Biometrics refers to the identification or verification of a person based on his/her physiological and behavioral characteristics. In contrast to the traditional security systems, which may be cracked or faked, current biometric technologies are based on various unique aspects of human body (such as the face, fingerprint, palmprint, iris, retina, voice, and gait).

Among these technologies face recognition is one of the most relevant applications of image processing. Human Face detection is the process of identifying the features of faces to detect the faces on the basis of the discriminant features. Features of faces are eyes, ears, eyebrows, nose, lips, hairs, chicks, forehead etc. Face detection can be carried out using these features of faces. Face is important part to identify the person. It can be used as the computer visual application. Face is the important part of our body by which it is easy to identify and recognize the person.

One of face recognition main goals is the understanding of the complex human visual system and the knowledge of how humans represent faces in order to discriminate different identities with high accuracy. Mainly face recognition falls into two main categories feature-based approach and holistic approach. Feature-based approach for face recognition basically relies on the detection and characterization of individual facial features and their geometrical relationships. Such features generally include the eyes, nose, and mouth. Holistic or global approaches to face recognition, on the other hand, involve encoding the entire facial image and treating the resulting facial "code" as a point in a high-dimensional space. The human face is a complex, natural object that tends not to have easily identified edges and features. Because of this, it is difficult to develop a mathematical model of the face that can be used as prior knowledge when analyzing a particular image.

Computational models of face recognition are interesting because they can contribute not only to theoretical knowledge but also to practical applications. According to the complexity of face detection process, many applications based on human face detection have been developed recently such as surveillance systems, digital monitoring, intelligent robots, notebooks, PC cameras, digital cameras and 3G cell phone. There are several techniques for face detection like Principal discriminant analysis (PCA), Linear discriminant analysis (LDA) ,Handsdorff distance measure for face recognition, Elastic Graph Matching (EGM), eigen space -based face recognition, a novel hybrid neural and dual eigen spaces methods, Fisher faces methods and artificial neural network.

II.RELATED WORK

On the analysis of face recognition system some of the important studies on face recognition systems are discussed. A multi-algorithm method is based on detecting the face of the individual by combining four algorithms namely PCA, DCT, Template Matching using Correlation and Partitioned Iterative Function System. Image quality based adaptive face recognition mainly used the multi-resolution property of wavelet transforms to extract facial features. Face detection based on features analysis and edge detection mainly consists of three phases including image preprocessing, skin color segmentation and finally the determination of face . A multi view face recognition system is based on eigenface using PCA to extract the features. This method used Cr space instead of gray level.

Another method for LDA based face recognition is based with selection of optimal components using E-coli bacterial foraging strategy (EBF). A GA-PCA algorithm was developed to find optimal eigenvalues and corresponding eigenvectors in LDA. A technique which combined weighted eigenface and BP based network

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divide the test face image into 9 sub blocks and then different weights were given to different parts of image according to their importance at recognition stage. A method based on hausdorff distance which compute eigen face from edge images showed that different face regions have different degree of importance in face recognition. For multidimensional data like 3-D images hidden markov eigen face model is proposed in which the eigen faces are integrated into seperable lattice hidden markov models.

III. FACE DETECTION & RECOGNITION

A general face recognition system include steps: face Detection, features extraction and face recognition. Face detection and recognition includes many complementary parts, each part is a complement to the other. Depending on regular system each part can work individually. Face detection takes images/video sequences as input and locates face areas within these images. This is done by separating face areas from non-face background regions. Facial feature extraction locates important feature (eyes, mouth, nose and eye-brows) positions within a detected face. Feature extraction simplifies face region normalization where detected face aligned to coordinate framework to reduce the large variances introduced by different face scales and poses. The accurate locations of feature points sampling the shape of facial features provide input parameters for the face identification. Other face analysis task: facial expression analysis, face animation and face synthesis can be simplified by accurate localization of facial features. Face identification generates the final output of complete face-recognition system, the identity of the given face image. Based on normalized face image and facial feature locations derived from previous stages, a feature vector is generated from given face and compared w ith a database of known faces. If a close match is found, the algorithm returns the associated identity.

IV.SYSTEM OVERVIEW

The proposed face recognition system consists of two phases which are the enrollment and recognition/verification phases as depicted in figure.

1) Image acquisition/ face detection module- Face detection is used to detect face and toextract the pertinent information related to facial features. The image will then be resized andcorrected geometrically so that it is suitable for recognition/verification. In this module, thebackground or the scenes unrelated to face will be eliminated.The outputs of the system are the rectangle which contains face features, and image which contains the extraction of the detection face features.

2) Face recognition / verification module The face recognition module comprises of preprocessing, feature extraction, and classification sub-modules. The input to the face recognition/verification module is the face image, which is derived from two sources: from the camera and from the database. From these sources, each image is preprocessed to get the geometric and photometric normalizedform of the face image. During feature extraction, the normalized image is represented as feature vectors. The result of the classification for the recognition purpose is determined by matching the client index with the client identity in the database.

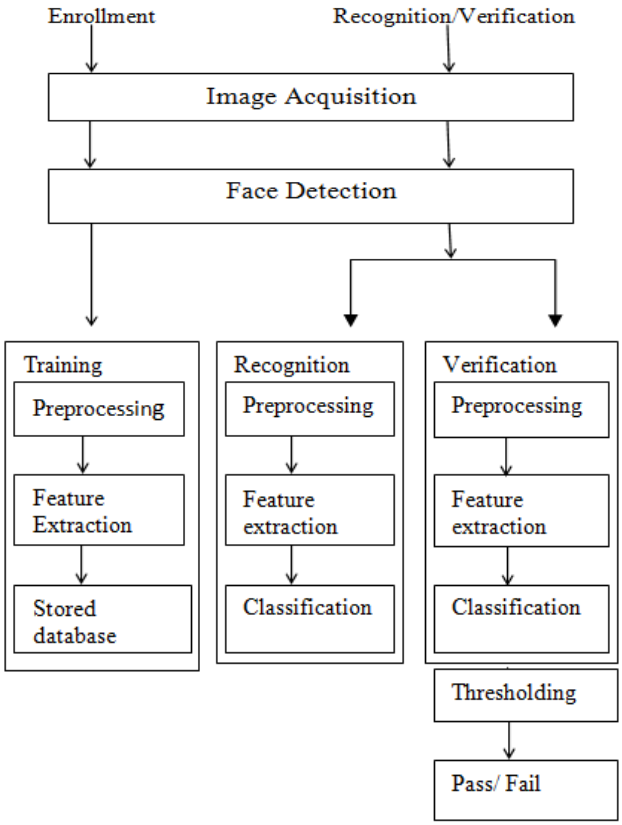

Figure 1: Block Diagram for the Proposed System

V.PROPOSED METHODOLOGY

In this paper two efficient techniques PCA and ANN have been merged for efficient face detection work. The proposed system mainly consist of three parts:

1. Preprocessing
2. Feature Extraction using PCA technique
3. Classification and Detection using ANN

A. Preprocessing-The purpose of the pre-processing module is to reduce or eliminate some of the variations in face due to illumination. It normalized and enhanced the face image to improve the recognition performance of the system. The photometric normalization consists of removing the mean of the geometrically normalized image and scaling the pixel values by their standard deviation, estimated over the whole cropped image. The photometric normalization techniques applied here is Histogram Equalization.

Histogram equalization

Histogram equalization is the most common histogram normalization or gray level transform, which purpose is to produce an image with equally distributed brightness levels over the whole brightness scale. It modifies the dynamic range (contrast range) of the image and as a result, some important facial features becomes more apparent.

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B. Features Extraction using PCA

The PCA algorithm is implemented for the extraction of image feature and dimensionality reduction**.** We assume that M sample images are being used. Each sample image is referred to as $\mathbf{A_n}$ where n indicates that we are dealing with nth sample image (1<n< M). Each $\mathbf{A_n}$ should be a column vector. Images are made of pixels, each having (x,y) coordinates with (0,0) being at the upper left corner.

Following are the steps involved in PCA:

Step 1: The size of the resulting $\mathbf{A_n}$ column vector will depend on the size of the sample images. If the sample images are x pixels across and y pixels tall, the column vector will be of size (x*y) × 1.

Step 2: Calculate the average image, **Ø**, as follows. This average image will be a column vector of the same size as the sample images ((x*y) × 1).

$$\mathbf{Ø} = \sum \mathbf{A_L}/\mathbf{M} \qquad \text{where } 1< L<M$$

Step 3: Calculate the difference faces by subtracting the average face from each sample image.Each will be a column vector the same size as our sample image vectors ((x*y)×1)

$$\mathbf{O} = \mathbf{A_n} - \mathbf{Ø}$$

Step 4: Total scatter matrix or covariance matrix is calculated from **Ø** .The covariance matrix is defined by $\mathbf{AA^T}$ where A is

$$\mathbf{A= [\ O_1\ O_2\ O_3 \ldots O_m]}$$

The matrix **A** will be of size (x*y) × M.

Step 5: The eigenvectors of this matrix can be found through the following formula:

$$\mathbf{u}_k = \frac{\sum_{l=1}^{M} \ddot{\mathbf{O}}_l \mathbf{X}_{lk}}{\sqrt{\lambda_k}}$$

u_k is the kth eigenface of the training data.

Step 6: For image classification this feature space can be utilized.Measure the vectors of weight which is found by multiplying the transpose of the matrix U by a vector that is found by subtracting the average face image Ø, from a sample or test image $\mathbf{A_n}$.

$$\mathbf{w= U^T(A - Ø)}$$

The weights form a vector $\mathbf{W^T}$ **= [w1,w2…..wm']** that describes the contribution of each eigenface in representing the input face image, treating the eigenface as a basis set for face images. This vector is used in a standard pattern recognition algorithm.

C. Classification and Detection using ANN

The purpose of the classification sub moduleis to map the feature space of a testdata to a discrete set of label data that servesas template. The classification techniquesused here is Artificial Neural Network.

Artificial neural networks (ANN)-ANN is a machine learning algorithmthat has been used for various patternclassification problems such as genderclassification, face recognition, andclassification of facial expression. The ANN takes the featuresvector as input, and trains the network tolearn a complex mapping for classification,which will avoid the need for simplifyingthe classifier.The ANN paradigm that isused in this application is Multilayer FeedforwardNeural Networks (MFNNs) or Perceptron.

Multi-Layer Perceptron (MLP) Network:-Here multilayer perceptron network is usedfor training and face detection.The network consist of input layer, hidden layer and output layer with tensing transfer function.The neural network learns the face patterns from the training data set and applies it for detecting face object from the query images.

VI.EXPERIMENTAL RESULTS

The system proposed here first select the image from the given dataset of the face images. After the image is selected segmentation is done followed by the thresholding. Then the feature extraction is performed and finally the matching is done to obtain the desired output. The image is read using the option present in the GUI. Once the image is read segmentation of the selected image is done which basically subdivides the image into its constituent regions or colour model. Then a threshold T is selected and the segmentation is accomplished by scanning the image pixel by pixel and labelling each pixel as object or background depending on whether the gray level of that pixel is greater or less than the value of threshold. We have used two generally used database for face recognition i.e. ORL database and AR database. ORL database include 400 face images taken from 40 subjects, with each subjects providing ten face images. For some subjects, the images were taken at different times, with varying lighting, facial expressions (open /closed eyes, smiling/not smiling) and facial details (glasses/ no glasses). Each face image from the ORL database has been resized to a 40 × 56 matrix by using the down sampling algorithm. In this some images are used for training samples and the remaining serves as the test samples. AR database takes some images as training samples and the remaining images are designated as the test samples. All images were cropped and resized to 92× 112 pixels. All the simulation results of the above steps are shown in this section.

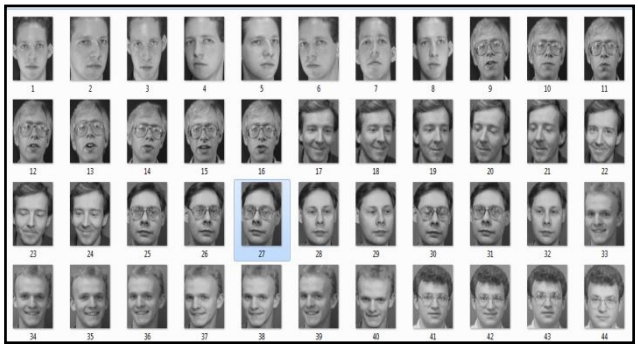

Figure 2: Training Database

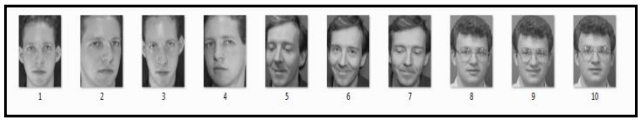

Figure 3: Testing Database

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The proposed system is very flexible and general system which can compare the two images either of the same person or of the different persons.

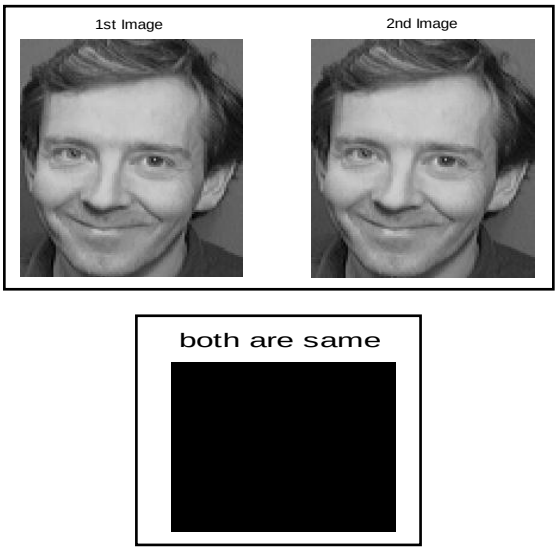


Figure 4. Face Recognized and detected as same image

Figure 4 shows the result when the same image is selected so the segmentation result be just a black component and result show that both are same. Another example shows the result when the two images are different.

Figure 5: a) Input image b) Image for testing c) Segmentation and d) Thresholding.

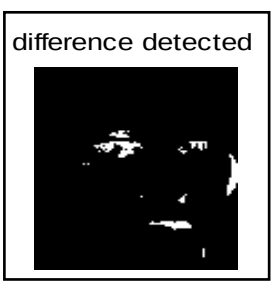
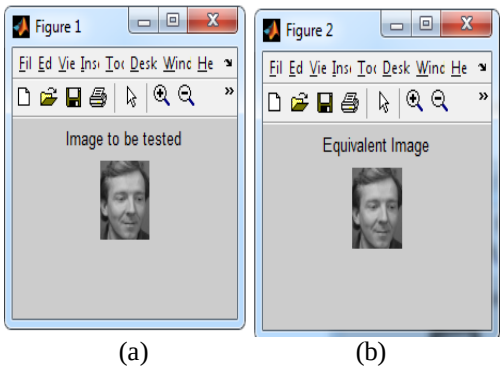


Figure 6 : Output Image

As the two images are different so segmentation is performed which will show the differences between the color components by comparing the pixel values of the image with the chosen threshold.

Training and Testing of Images



(a) (b)

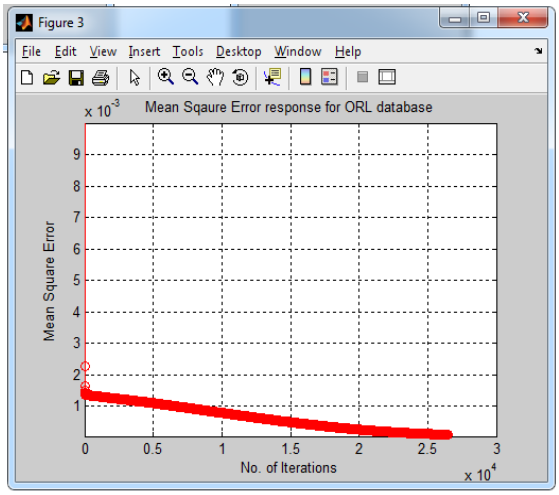


Figure 7**:** a) Input image b) Output Image c) MSE response

VII. CONCLUSION AND FUTURE SCOPE

This work investigated a promising method of face recognition by merging two techniques PCA, which is used here for feature extraction, and ANN, which is used here for recognition and verification purpose. The principal component analysis method for face recognition is motivated by information theory approach that decomposes face images into a small set of characteristics features images called "eigen faces" which may be thought of as the principal components of the initial training set of face images. The ANN is used as a classifier here, which will map the feature space of a test data to a discrete set of label data that serves as database. This technique is fast, accurate and has an advantages for classification such as incredible generalization and good learning stability. The ANN paradigm used in this application is Multilayer Feed forward Neural Network (MFNNs).This algorithm also attempts to minimize the squared error function. The simulation results shows that the proposed algorithm is very efficient in comparing the images either of the same person with variations in facial expressions or between the images of different persons.

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The experiment is done on two widely used dataset and the results also shows that the goal set for the mean square error is achieved after some iterations.

With the synergy of efforts from researchers in diverse fields including computer engineering, mathematics, neuroscience, and psychophysics different frameworks have evolved for solving the problems of face recognition. The research can be extended to implement face detection technique to facilitate real time feature extraction. This thesis used ANN as the classifier so another classifier Support Vector Machine can be also used as an extension of this work. This work can also be extended by using boosting and bagging in the same context and then compare it with the proposed hybrid approach.

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