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An Efficient Face Recognition Technique Using PCA and Artificial Neural Network

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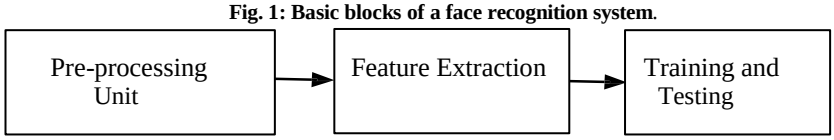
Abstract: *Face recognition is one of the biometric tool for authentication and verification. It is having both research and practical relevance. . Face recognition, it not only makes hackers virtually impossible to steal one's "password", but also increases the userfriendliness in human-computer interaction. Facial recognition technology (FRT) has emerged as an attractive solution to address many contemporary needs for identification and the verification of identity claims. A facial recognition based verification system can further be deemed a computer application for automatically identifying or verifying a person in a digital image.The two common approaches employed for face recognition are analytic (local features based) and holistic (global features based) approaches with acceptable success rates. In this paper, we present a hybrid features based face recognition technique using principal component analysis technique.Principal component analysisis used to compute global feature while the local feature are computed configuring the central moment and Eigen vectors and the standard deviation of the nose,mouth and eyes segments of the human face as the decision support entities of Artificial neural network.*

Keywords: *face recognition; analytic approach; holistic approach; hybrid features; artificial neural network; central moment; eigen vectors; standard deviation*

I. Introduction

Biometrics refers to a science of analyzing human body parts for security purposes. The word biometrics is derived from the Greek words *bios* (life) and *metrikos* (measure).Biometric identification is becoming more popular of late owing to the current security requirements of society in the field of information, business, military, e-commerce and etc. For our use, biometrics refers to technologies for measuring and analyzing a person's physiological or behavioral characteristics. These characteristics are unique to individuals hence can be used to verify or identify a person. In general, biometric systems process raw data in order to extract a template which is easier to process and store, but carries most of the information needed. Face recognition is a nonintrusive method, and facial images are the most common biometric characteristics used by humans to make a personal recognition. Human faces are complex objects with features that can vary over time. However, we humans have a natural ability to recognize faces and Indentify person at the spur of the second. Of course, our natural recognition ability extends beyond face recognition too. In Human Robot Interface [3] or Human Computer Interface (HCI), the machines are to be trained to recognize and identify and differentiate the human faces. There is thus a need to simulate recognition artificially in our attempts to create intelligent autonomous machines. Recently face recognition is attracting much attention in the society of network multimedia information access. Basically, any face recognition system can be depicted by the following block diagram.

Fig. 1: Basic blocks of a face recognition system.



1) Pre-processing Unit: In the initial phase, the image captured in the true colour format is converted to gray scale image and resized to a predefined standard and noise is removed. Further Histogram Equalization (HE) and Discrete Wavelet Transform (DWT) are carried out for illumination normalization and expression normalization respectively [4].

2) Feature Extraction: In this phase, facial features are extracted using Edge Detection Techniques, Principal Component Analysis (PCA) Technique, Discrete Cosine Transform (DCT) coefficients, DWT coefficients or fusion of different techniques [5].

3) Training and Testing: Here, Euclidean Distance (ED), Hamming Distance, Support Vector Machine (SVM), Neural Network [6] and Random Forest (RF) [7] may be used for training followed by testing the new images or the test images for recognition.

The popular approaches for face recognition are based either on the location and shape of facial attributes such as the eyes, eyebrows, nose, lips and chin, and their spatial relationships, or the overall analysis of the face image that represents a face as a weighted combination of a number of canonical faces.

In the former approach the local attributes of the face are considered in training and testing while the latter approach reckons in the information derived from the whole.The local features based approach demand a vast collection of database images for effective training thus increasing the computation time. The global technique works well with frontal view face images but they are sensitive to translation, rotation and pose changes.

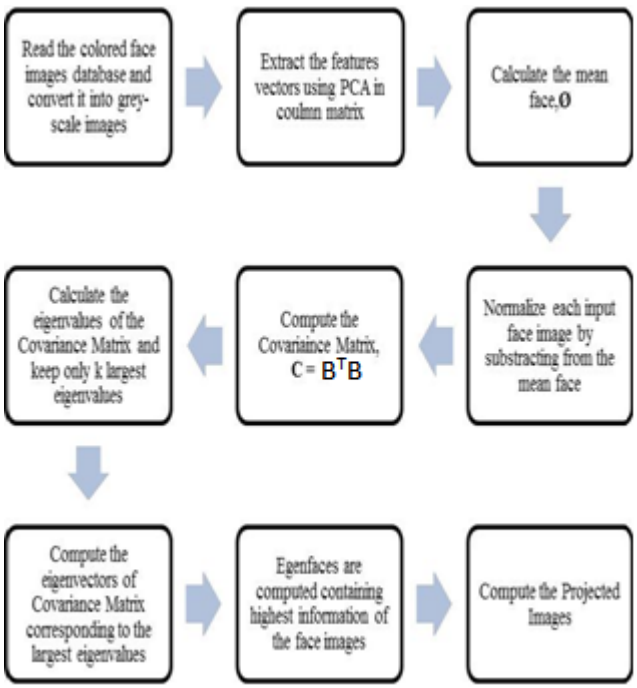
Since, these two approaches do not give a complete representation of the facial image, hybrid features based face recognition system using principal component analysis and artificial neural network is designed.

This paper presents the face recognition method using PCA that extracts the geometrical features of the biometrical characteristic of the face such as eyes, nose, and mouth and the overall analysis of the whole face. After the pre-processing stage, segments of the eyes, nose and mouth are extracted from the faces of the database. These blocks are then resized and the training features are computed. These facial features reduce the dimensionality by gathering the essential information while removing all redundancies present in the segment. Besides, the global features of the total image are also computed. These specially designed features are then used as decision support entities of the classifier system configured using the Artificial neural network.

II. Principle Component Analysis

Features of the face images are extracted using PCA in this purposed methodology. PCA is dimensionality reduction method and retain the majority of the variations present in the data set. It capture the variations the dataset and use this information to encode the face images. It computes the feature vectors for different face points and forms a column matrix of these vectors. PCA algorithm steps are shown in Fig 2.

Fig. 2: Features Extraction using PCA by computing the Eigenface Images



PCA projects the data along the directions where variations in the data are maximum. The algorithm is follows as:

- Assume the m sample images contained in the database as $\mathbf{B_1, B_2, B_3……B_m}$.
- Calculate the average image, Ø, as: $\mathbf{Ø= \sum B_l /M,}$ where 1< L<M, each image will be a column vector the same size.
- The covariance matrix is computed as by $\mathbf{C = B^T B}$ where $\mathbf{B = [O_1\ O_2\ O_3….O_m]}$.
- Calculate the eigenvalues of the covariance matrix **C** and keep only **k** largest eigenvalues for dimensionality reduction as $\lambda_k = \sum^{m}_{n=1}(U_K^T\ O_n)$.
- Eigenfaces are the eigenvectors U_K of the covariance matrix C corresponding to the largest eigenvalues.

- All the centered images are projected into face space on eigenface basis to compute the projections of the face images as feature vectors as: $\mathbf{w} = \mathbf{U}^T\mathbf{O} = \mathbf{U}^T(\mathbf{B_i} - \mathbf{Ø})$, where $1< i<m$.

PCA method computes the maximum variations in data with converting it from high dimensional image space to low dimensional image space. These extracted projections of face images are further processed to Artificial Neural Networks for training and testing purposes.

III. Eigenvector with Highest Eigen Value

An eigenvector of a matrix is a vector such that, if multiplied with the matrix, the result is always an integer multiple of that vector. This integer value is the corresponding Eigenvalue of the eigenvector. This relationship can be described by the equation:

$M \times u = \times u$, where u is an eigenvector of the matrix M is the matrix and is the corresponding Eigenvalue. Eigenvectors possess following properties:

- They can be determined only for square matrices.
- There are n eigenvectors (and corresponding Eigenvalues) in an $n \times n$ matrix.
- All eigenvectors are perpendicular, i.e. at right angle with each other.

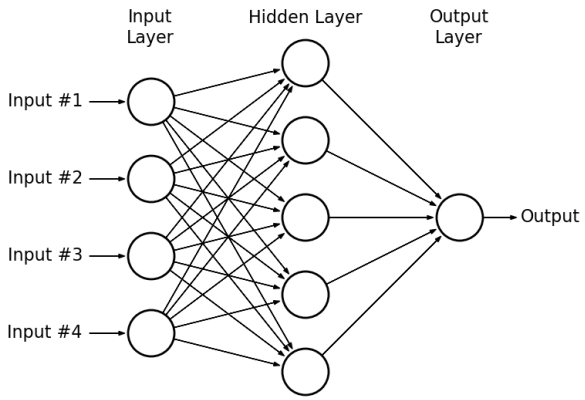
The traditional motivation for selecting the Eigenvectors with the largest Eigenvalues is that the Eigenvalues represent the amount of variance along a particular Eigenvector. By selecting the Eigenvectors with the largest Eigenvalues, one selects the dimensions along which the gallery images vary the most. Since the Eigenvectors are ordered high to low by the amount of variance found between images along each Eigenvector, the last Eigenvectors find the smallest amounts of variance. Often the assumption is made that noise is associated with the lower valued Eigen values where smaller amounts of variation are found among the images .

IV. Artificial Neural Network

Artificial neural networks, commonly referred to as "neural networks", has been motivated right from its inception by the recognition that the brain computes in an entirely different way from the conventional digital computer . A neural network is built-up on neurons, which are the basic information treating units. These do a weighted linear combination of their inputs and pass the sum through an activation function of sigmoid type, which acts as a switch and propagates a given input activation further or suppresses it. In order to be able to detect faces, a neural network must first be trained to handle this task.

There are differ types of ANN. Some of them are Kohonen networks, Radial Basis Function and Multilayered Perceptron. The multilayered feed forward neural network is shown in Figure 3. It consist of three layers namely input layer, hidden layer and output layer. These layers of processing elements make independent computation of data and pass it to another layer. The computation of processing elements is completed based on weighted sum of the inputs. The output is then compared with the target value and calculation of the mean square error is carried out which is processed back to the hidden layer to tune its weights. Iteration of this process occurs for each layer in order to minimize the error by continually tuning the weight of each layer. Hence, it is known as the back propagation. The iteration process carried out till the error falls below the threshold level.

Fig. 3: Multilayered feed-forward network configuration

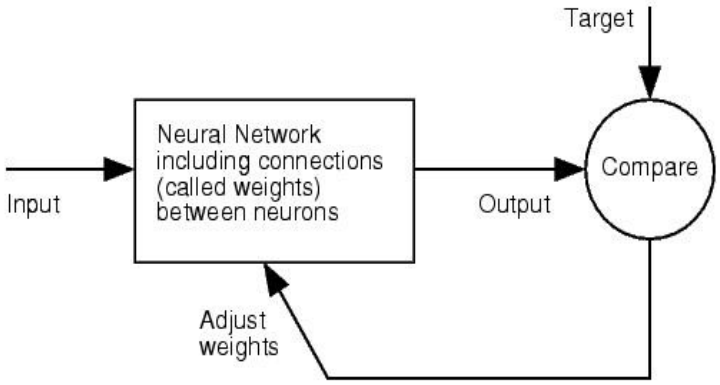


In face recognition system that uses ANN, the configuration works in the following frames:-

 Input to Feed Forward Network: - Here the parameters are selected to perform required Neural Networks operation i.e. the number of input layers, hidden layers and output layers. These input neurons receives the data from the training set of face images.

 Back Propagation and weight Adjustment: - The input layer processes the data to the hidden layer. The hidden layer computes the data further and then passes it to the output layer. Output layer compares it with that of target value and obtain the error signals. These errors are sent back for weight adjustments of each layer to minimize the error as shown in Fig. 4.

Fig. 4: Back Propagation of multilayered ANN

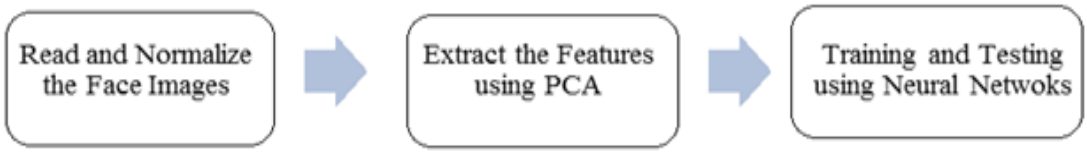


 Mathematical Operation: - It performs the mathematical function on the output signal. The functions can be log-sigmoid, threshold function and Tangent hyperbolic function. If the output values of the function are same as that of the output values of the Tested face, the face is detected. Hence, the Neural Networks provides the response to the input which is alike as the training data.

V. IMPLEMENTATION PROCESS

In this work, PCA technique is used to extract the features of the face images. PCA extracts the variations in the features of face images which contains the highest information with decomposed dimensions.

Fig5. Basic blocks for Face Recognition



Extracted features calculate the eigenfaces.These eigenfaces are taken as input to the Artificial Neural Networks for training the neural networks. For testing basis, the eigenface of the tested image is provided as input to the neural networks that are trained and it finds the best match considering the threshold value for rejecting the unknown face images.

VI. RESULTS

We applied each feature extraction method with Artificial neural network on the SDUMLA-HMT face database. We ex-tracted PCA feature vectors with an application program coded using Matlab 7.0.Tests were done on a PC with Intel Pentium D 2.8-GHZ CPU and 1024-MB RAM. In this study, standard SDUMLA-HMT database images (10 poses for each of 40 people) were converted into JPEG image format without changing their size. For both feature extraction methods a total of six train-ing sets were composed that include varying pose counts (from 1 to 6) for each person and remaining poses are chosen as the test set. Our training sets include 40, 80, 120, 160, 200 and 240 images according to chosen pose count. For each person, poses with the same indices are chosen for the corresponding set. The results obtained are tabulated in Table 1 which shows that the proposed technique is more efficient than face recognition technique using PCA and Support Vector Machine(SVM)

Table1: Improvement from the Face Recognition System using PCA and SVM

Type of technique	Recognition rate (in %)	Error rate on the evaluation set (in %)	Half total error rate on the evaluation set (in %)	Verification rate at 1% FAR (in %):	1% FAR on the test set equals (in %)
PCA and SVM	85.52	6.64	6.12	50.00	54.14
PCA and ANN	92.99	3.03	2.70	95.49	94.95

Fig. 6: Recognition rate

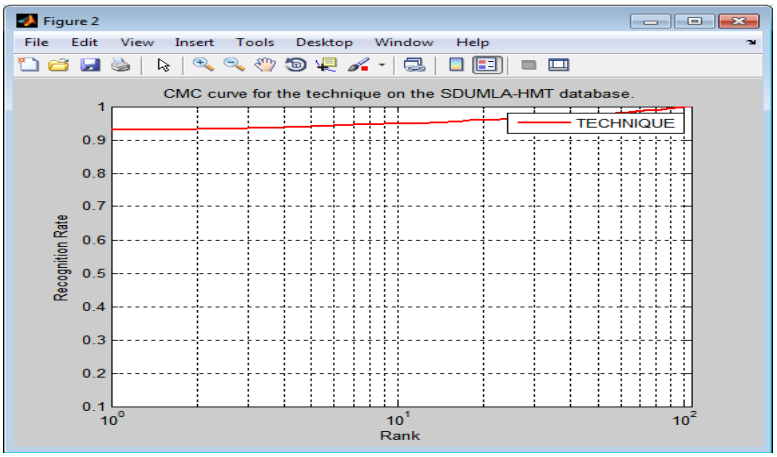


Fig. 7: Error rate

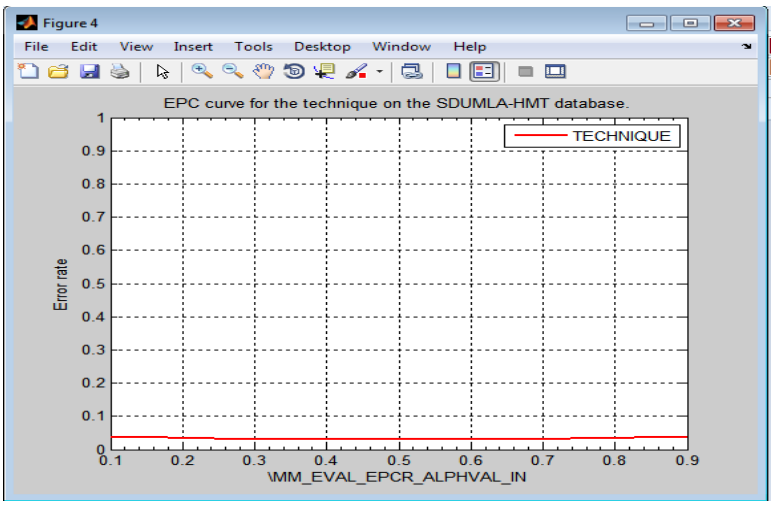
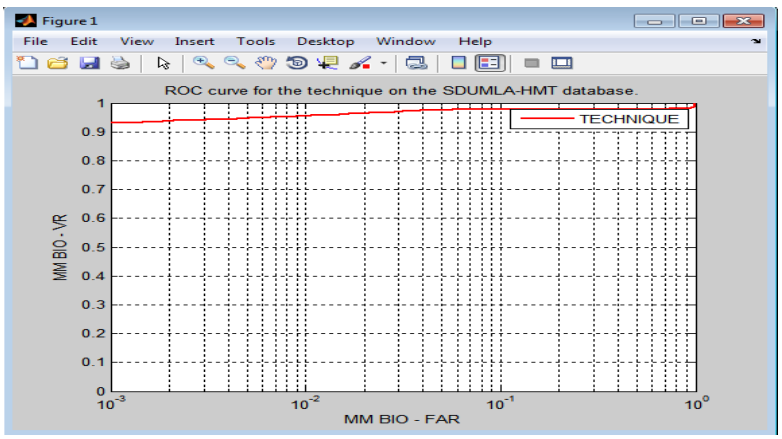


Fig. 8: Verification rate



VII. CONCLUSION

In this paper, a new Face recognition method is presented. The new method was considered as a combination of PCA, and Artificial neural network. We used these algorithms to construct efficient face recognition method with a high recognition rate. Proposed method consists of following parts: image preprocessing that includes histogram equalization, normalization and mean centering, dimension reduction using PCA that main features

that are important for representing face images are extracted,and artificial neural network algorithm is employed to train the database. The ANN takes the features vector as input, and trains the network to learn a complex mapping for classification.Simulation results using SDUMLA-HMT face datasets demonstrated the ability of the proposed method for optimal feature extraction. Hence it is concluded that this method has the recognition rate more than 90 %.

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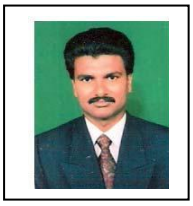

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