Face Recognition using algorithm and Fusion of PCA and ANN

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Abstract - In real-world face detection, large visual variations, such as those due to pose, expression, and lighting, demand an advanced discriminative model to accurately differentiate faces from the backgrounds. Consequently, effective models for the problem tend to be computationally prohibitive. The proposed methodology is implemented in two stages. The first stage detects the human face in an image using violaJones algorithm. In the next stage the detected face in the image is recognized using a fusion of Principle Component Analysis and Feed Forward Neural Network. The performance of the proposed method is compared with existing methods. Better accuracy in recognition is realized with the proposed method. The proposed methodology uses Bio ID-Face-Database as standard image database.

Keywords: Face recognition, Principal Component Analysis, Artificial Neural Network, Viola-Jones algorithm.

I. INTRODUCTION

Face recognition is a major challenge encountered in multidimensional visual model analysis and is a hot area of research. The art of recognizing the human face is quite difficult as it exhibits varying characteristics like expressions, age, change in hairstyle etc [1]-[5]. Face recognition plays a crucial role in applications such as security system, credit card verification, identifying criminals in airport, railway stations etc [6]. Although many methods have been proposed to detect and recognize human face developing a computational model for a large data base is still a challenging task. That is why face recognition is considered as high-level computer vision task in which techniques can be developed to achieve accurate results. Few popular methods known for face recognition are neural network group-based tree [7], neural nets, artificial neural networks [8] and principal component analysis [9]. The proposed methodology is implemented in two stages. Since the human face can be identified by certain facial characters in the first step the relevant features from the facial image are extracted. They are then quantized so that it will be easy to recognize the face form these features. For face detection viola-Jones algorithm which works on Haar features and Ada boost classifier as modifier is used. To recognize the face detected fusion of principal component analysis algorithm and artificial neural network are used to obtain accurate results. The aim of the proposed methodology is to detect the face in an image and identify the person using a standard image database with a better efficiency and accuracy in comparison with the existing methods.

II. RELATED WORK

Muhammad Murtaza Khan et al.,[10] proposed a scheme which enhances the recognition rate as compared to PCA. The proposed scheme, sub-Holistic PCA out performed PCA for all test scenarios. A recognition rate of 90% is realized for ORL data base. Patrik Kamencay et al.,[11] proposed a methodology for face recognition based on preprocessing face images using Belief Propagation segmentation algorithm. The proposed algorithm shows that the segmentation has a positive effect for face recognition and a recognition rate of 84% for ESSEX database is realized. Hala M. Ebied et al.,[12] proposed use of linear and nonlinear methods for feature extraction in the face recognition system. The Kernel-PCA is extended from PCA to represent nonlinear mapping in a higher-dimensional feature space. The K-nearest neighbor classifier with Euclidean distance is used in the classification step. Patrik Kamencay et al.,[13] proposed face recognition using SIFT-PCA method and impact of graph-based segmentation algorithm on recognition rate. Preprocessing of face images is performed using segmentation algorithm and SIFT. The results show that segmentation in combination with SIFT-PCA has a positive effect for face recognition. Rammohan Mallipeddi et al.,[14] proposed NP-hard problem of finding the best subset of the extracted PCA features for face recognition is solved by using the differential equation algorithm and is referred to as FS-DE. The feature subset is obtained by maximizing the class separation in the training data and also presented an ensemble based for face recognition. Swarup Kumar Dandpat et al.,[15] proposed a high-performance face recognition algorithm and tested it using PCA and two dimensional PCA. Different weight is assigned to the only very few non zero

Eigen values related eigenvectors which are considered as non-trivial principal components for classification. Face recognition task was performed using k-nearest distance measurement. Firoz Mahmud et al., [16] proposed an approach to recognize a face using PCA based Genetic Algorithm. The PCA is applied to extract features from images with the help of covariance analysis to generate Eigen components of the images and reduce the dimensionality. Genetic Algorithm gives the optimal solution from the generated large search space. Mohammad A. U. Khan et al.,[17] proposed face recognition method based on PCA and Directional Filter Bank responses. Directional images are created from the original face image using DFB and they are transformed into Eigen space by PCA, which is able to optimally classify individual facial representation. Recognition ability of PCA is enhanced by providing directional images as inputs. Jia-Zhong He et al.,[18] proposed image enhancement based PCA method to deal with face recognition with single training image per person. The method combines the original training image with its reconstructed image using only a very few low-frequency DCT coefficients and then perform PCA on the enhanced data set. Akrouf Samir et al., [19] proposed face recognition using a hybrid method combining PCA and DCT. The basic idea is to encode the initial data to pass to another space of dimensions much more reduced while preserving useful information. Md.Omar Faruqe et al.,[20] proposed face recognition using PCA and SVM. PCA is used as feature extractor and SVMs are used to tackle the face recognition problem. SVMs are proposed as a new classifier for pattern recognition. The performance Polynomial and Radial Basis Function SVMs is better as compared to other SVMs. Girish G N et al.,[21] compared face recognition methods using local features and global features. The local features were derived using Multi Scale Block Local Binary Patterns and global features are derived using PCA. For each facial image a spatially enhanced, concatenated representation was obtained by deriving a histogram from each grid of divided input image. These histograms were projected to lower dimensions by applying PCA. The global face representation is derived by projecting several images of the subject in to lower dimensions applying PCA. Dr. S. Ravi et al.,[22] compared two basic and important appearance-based face recognition methods viz, PCA and LDA. These two techniques have been implemented and evaluated with different databases and the outputs are compared using accuracy rate. Abhjeet sekhon et al.,[23] proposed back propagation based artificial neural network learning algorithm for recognizing human faces. A facial recognition system is proposed to recognize registered faces in the database and new faces that are not part of the database. Hayet Boughrara et al.,[24] proposed study of modified constructive training algorithm for Multi-Layer Perceptron which is applied to face recognition applications. The contribution of this paper is to increment the output neurons simultaneously with incrementing the input patterns. The proposed algorithm is applied in classification stage. For the feature extraction Perceived Facial Images is applied. Mitsuharu Matsumato [25] proposed a contrast adjustment face recognition system using neural network. Parameter setting is realized using correlation and statistical independence. Subjective information such as face in the image is directly applied with face recognition system as evaluation function for parameter setting. Raman Bhati [26] proposed a new to achieve the optimum learning rate which can reduce the learning time of the multi-layer feed forward neural network. The PCA and Multilayer Feed Forward Network are applied in face recognition system for feature extraction and recognition respectively. Recognition rate and training time are dependent on number of hidden nodes. Variable learning rate is used over constant learning rate to realize this. Dhirender Sharma et al.,[27] proposed a two-step modular architecture which provides improvised matching score. At the first step the facial image is decomposed into three sub-images. At the second stage sub-image is solved redundantly by two different neural network models and feature extraction techniques.

III. PROPOSED METHODOLOGY

The proposed method implements an efficient Face Detection and Recognition technique which is independent of variations in features like color, hairstyle, different facial expressions etc using Viola Jones algorithm, PCA and ANN. The process flow of the proposed methodology is as shown in Figure 1.

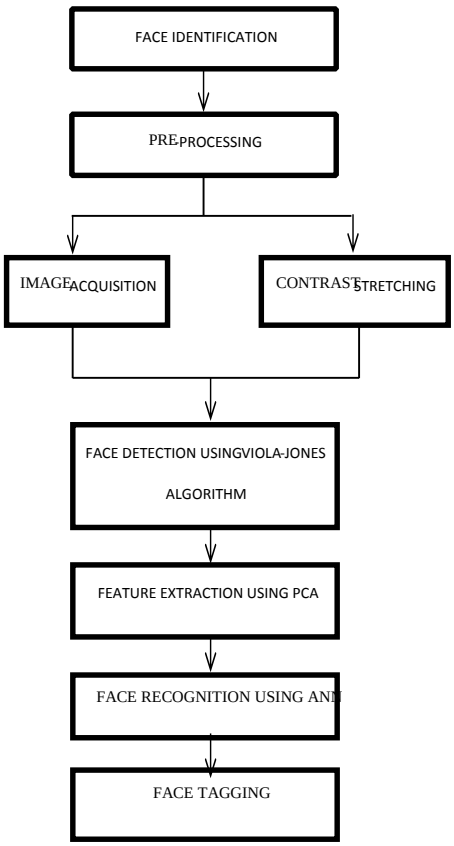

Figure 1: Flowchart of the proposed methodology

The proposed methodology uses the BioID Face Database as the standard image data base. The dataset consists of 1521 gray level images with resolution of 384*286 pixel and frontal view of a face of 23 different persons. The test set features a large variety of illumination, background and face size representing real world conditions as shown in Fig 2.

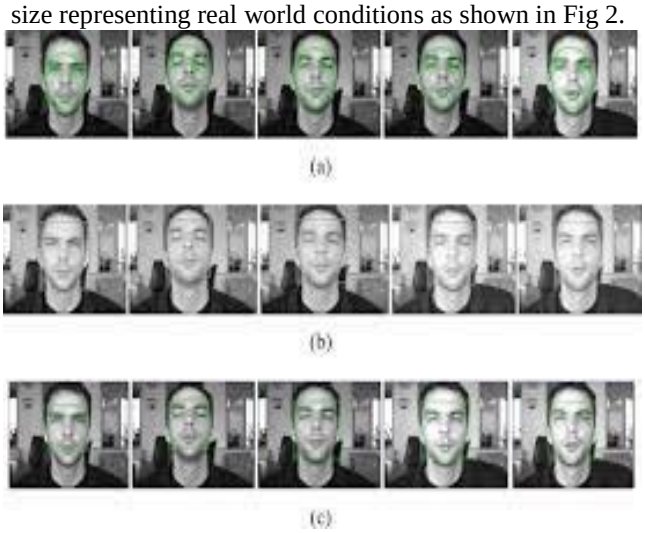

Figure 2: BioID Face Database

Pre-Processing:

A standard image database which is readily available either in color or gray scale is considered. In the Pre-processing stage contrast stretching is performed on the acquired image where the white pixels are made whiter and black pixels are made blacker.

Face Detection:

After contrast stretching viola-Jones algorithm is applied for detecting the face in the image. Viola-Jones detector was chosen as a detection algorithm because of its high detection rate, and its ability to run in real time. Detector is most effective on frontal images of faces and it can cope with 45° face rotation both around the vertical and horizontal axis. The three main concepts which allow it to run in real time are the integral image, Ada Boost and the cascade structure. The Integral Image is an algorithm for cost-effective generation of the sum of pixel intensities in a specified rectangle in an image. It is used for rapid computation of Haar-like features. Calculation of the sum of a rectangular area inside the original image is extremely efficient, requiring only four additions for any arbitrary rectangle size. AdaBoost is used for construction of strong classifiers as linear combination of weak classifiers.

The Haar features used in voila-Jones algorithm are as shown in Fig 3.

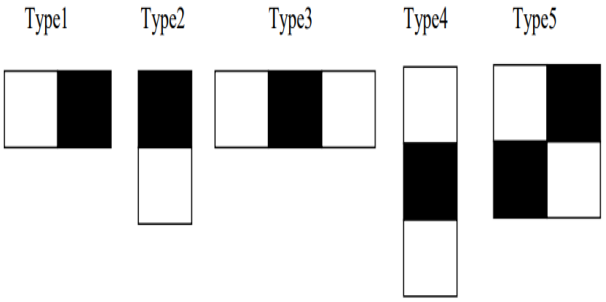

Figure3: Haar features in viola-Jones.

The above Haar features can be of various height and width. From the Haar feature applied to the face the sum of black pixel and sum of white pixel are calculated and they are subtracted to get a single value. If this value is more in that region, then it represent a part of the face and is identified as eyes, nose, cheek etc.

Haar features are calculated all over the image which will be almost 160000+ features per image. Summing up the entire image pixel and then subtracting them to get a single value is not efficient in real time applications. This can be reduced by using Ada boost classifier. Ada boost reduces the redundant features. Here instead of summing up all the pixels the integral image is used as shown in figure 4.

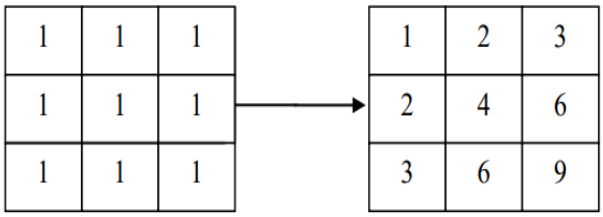

Figure 4: Integral image

To get a new pixel value the top pixels and left pixels are added then all the values around the patch are added to obtain the sum of all pixel value.

Ada boost determines relevant features and irrelevant features. After identifying relevant features and irrelevant features the Adaboost assigns a weight to all of them. It constructs a strong classifier as a linear combination of Weak classifiers.

Weak classifier = { 1; Identified a feature (ex: nose)
0; Not Identified any feature (ex: no nose in image)

Almost 2500 features are calculated. Further the number of computations can be reduced by cascading. Here set of

features are kept in another set of classifier and so on in a cascading format. By this method one can detect whether it is a face or not in a quicker time and can reject it if one classifier fails to provide a required output to the next stage. The detected face is cropped and resized to a standard resolution of 100x100. The next step is to identify the detected image using principle component analysis and artificial neural network algorithm.

Feature Extraction:

PCA is used to extract features from an image of human face. The Flow chart of PCA Algorithm is as shown in the Fig 5.

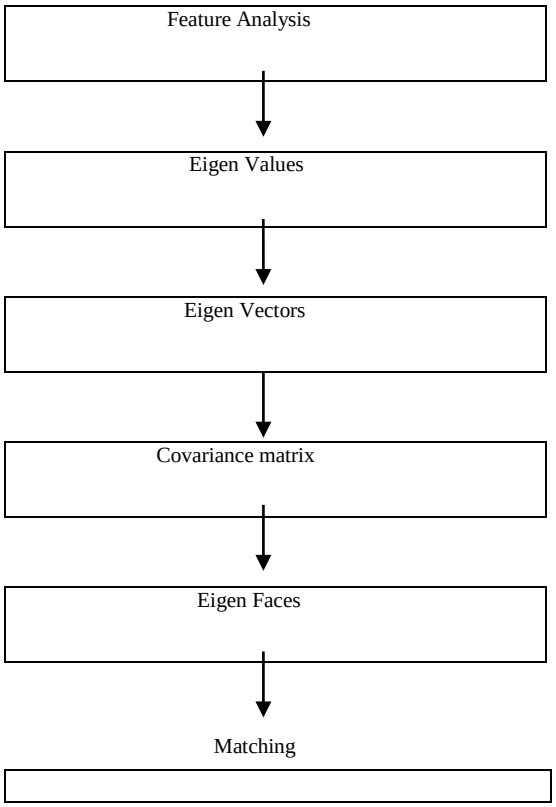

Figure 5: Flow chart of PCA Algorithm

Principal component analysis (PCA) algorithm is used to extract features from a cropped and resized face image. It is used as a tool in predictive analysis and in explanatory data analysis and is used to transform higher dimensional data into lower dimensional data. A bunch of facial images in a training set of size M x M are converted into lower dimensional face images by applying principal component analysis technique.

Principal component analysis is one of the mathematical procedures used to convert a set of correlated N variables into a set of uncorrelated k variables called as principal components. The number of principal components will be less than or equal to number of original values i.e., K<N. For the face recognition application, the above definition is modified as Principal component analysis is one of the mathematical procedures used to convert a set of correlated N face images into a set of uncorrelated k face images called as Eigen faces.

To reduce the number of calculations the dimension of the original images has to be reduced before calculating the principal components. Since principal components show less direction and more noise, only first few principal components (say N) are selected and the remaining components can be neglected as they contain more noise.

A training set of M images is represented by the best Eigen faces with largest Eigen values and accounts for the most variance with in the set of face images and best approximate the face. After finding Eigen faces each image in training set can be represented by a linear combination of Eigen faces and will be represented as vectors. The input image features are compared with standard database features for recognition.

Face Recognition:

In this stage the data taken from the images are simulated using a previously trained ANN. The input will be a vector array from the previous stage. The networks are trained with face descriptors as input. The number of network will be equal to the number of persons in the database.

To understand the concept of Artificial Neural Networks, one should know how the natural neural network system in brain works. Natural Neural Networks system in the brain has neurons as the basic building blocks. All neurons are connected by a path to carry electrical signals referred to as synapses. They communicate through these paths and approximately there are 100 billion neurons in a brain. Each cell has inputs and outputs.

In a similar way the computer created artificial network has inputs for inserting the data, outputs for providing the network output and hidden layer for processing the data and training of the network as shown in Figure 6.

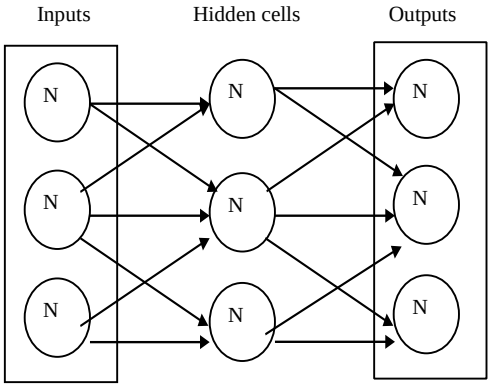

Figure 6: Artificial Neural Networks

The number of neurons in the input layer is equal to number of Eigen faces, number of neurons in the hidden layer is 10 and the type is Feed forward back propagation network.

Consider an individual cell represented as f(x) its output can be calculated as output= input1 + input2 as shown in Figure 7. The function f(x) is a neutral function as it won't add or amplify any value to the incoming inputs but it just adds the value of incoming inputs. One can use a mathematical function such as tanh to represent the above function.

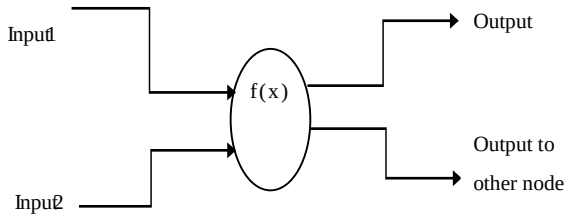

Figure 7: Individual neuron cell

The back propagation algorithm is used in layered feed forward ANN. Here neurons send their signals in forward direction and the errors are propagated backwards. The back propagation reduces this error until ANN learns the training data. The neural networks learn through the back propagation technique and determine the connection weights between the inputs, outputs and hidden cells. The random weights are initially assigned to these networks which are to be adjusted so that the error is minimal.

Desired output – Calculated output = Difference error in network

To minimize the error back propagation technique is used. This technique uses a formula which consists of weights, inputs, outputs, error and learning rate (α) to minimize the error.

Training of Neural Networks:

One ANN is used for each individual in the data base considered. Since there are twenty three persons in the data base twenty three networks are created. For training of ANN face descriptors are used as input. The face descriptors belonging to the same individual are used as positive examples for that individual network so that output will be 1 and as negative example for others so that output will be 0. The trained network will be used for the recognition purpose.

Simulation of Neural Networks:

Face descriptors of the test image calculated from the Eigen faces are applied as input to all the networks and they are simulated. Simulated results are compared and a maximum output greater than a predefined threshold level confirms that the test image belongs to the recognized person with the maximum output.

Face Tagging:

In the Face Tagging stage, the result from the simulation is used by the recognition system to tag an appropriate name to the image of the person. The data is in binary form and hence this block is also responsible in evaluating the expression into a certain value and matching it to a person's name in the name list. However, if the interpreted value is not one of the values listed in the roster, then the name returned will be automatically predefined as "Unknown".

IV. RESULTS AND ANALYSIS

Consider an image from the Bio ID-Face-Database as shown in Figure 8, it is pre-processed for identification.

Figure 8: Reference image from BioID database.

Applying the Voila-Jones algorithm to the image in Figure 8, Identified face image shown in Figure 9 is obtained (bounding box on identified face). It is then resized to 100x100 pixels that is the Haar features are calculated and all the related features are extracted.

Figure 9: Face identified by Voila-Jones algorithm (Red boundary).

Main features of the face are identified by Voila-Jones algorithm marked by a bounding box as shown in Figure 10 and is used for deciding the nodes corresponding to the identified part of the face.

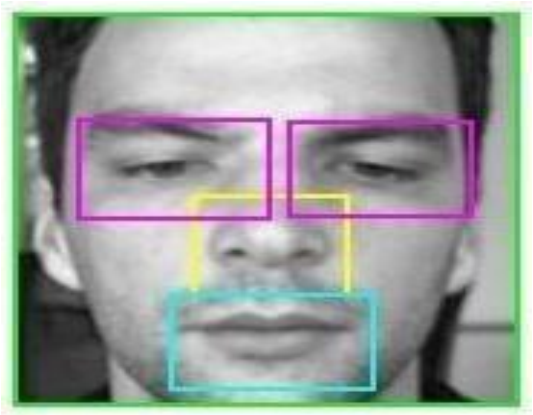

Figure 10: Face features (parts) identified by Voila-Jones algorithm (Boundary box).

The features extracted by Voila-Jones algorithm are represented as nodes and these nodes are joined to form a shape making sure that all nodes are connected, and the connected lines are named with reference numbers as shown in the Figure 11.

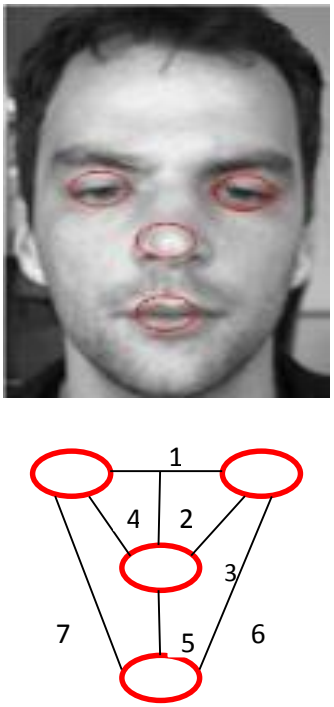

Figure 11: Face feature calculation

Figure 11 shows the details of feature calculation in a face to identify the person. The features are calculated from various angles and each detail is tabulated. Based on this the person in the image is identified. The tabulated results of the various features carried out are shown in Table 1.

Table 1: Various feature calculation

	Face features of Images Vs Different angles						
	1	2	3	4	5	6	7
1	883	355	522	521	654	567	579
2	861	382	522	523	653	571	589
3	1922	369	529	511	649	637	645
4	1925	353	511	598	632	617	612
5	1119	418	694	611	719	638	653
6	1942	384	554	542	711	584	587
7	1911	361	559	545	665	699	611
8	1957	341	513	516	655	618	616
9	1191	325	448	465	631	629	631
10	1981	332	517	526	657	611	625
11	1942	319	471	488	625	578	691
12	1996	363	516	511	659	575	583
13	1933	244	491	419	541	612	618
14	1931	391	438	442	612	621	637
15	1867	359	511	598	631	551	547

V. CONCLUSION

The paper presents an efficient approach for face detection and recognition using Viola-Jones, fusion of PCA and ANN techniques. The performance of the proposed method is compared with other existing face recognition methods and it is observed that better accuracy in recognition is achieved

with the proposed method. Face detection and recognition plays a vital role in a wide range of applications. In most of the applications a high rate of accuracy in identifying a person is desired hence the proposed method can be considered in comparison with the existing methods.

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