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Face Detection and Recognition using Viola-Jones algorithm and fusion of LDA and ANN

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Abstract: *Building a computational model for recognizing a face is a complicated task as the face is a complex multidimensional visual model. The proposed paper focuses on human face recognition by calculating the features present in the image and identifying the person using these features. Face detection and identification is performed in two stages. In the first stage, presence of face in a given image is detected using Viola-Jones algorithm and in the next stage, the detected face is identified using Linear Discriminative Analysis (LDA) and Artificial Neural Network (ANN). Proposed methodology uses fusion of LDA and ANN and best identification rate is realized in comparison with the existing methods. Bio ID-Face-Database is used as the standard image database.*

Keywords: *Artificial Neural Network, Face recognition, Linear Discriminative Analysis, Viola-Jones algorithm.*

I. Introduction

Identifying the human face is a prominent challenge faced in machine recognition. Face recognition is the most vital area of research in computer vision, machine recognition, psychology and neuroscience. Face recognition and identification is an active field of interest as it finds application in the field of security, checking system at airports, railway stations, teleconferencing, defense etc[1].

The rapid development in the area of face detection and identification is due to the development of efficient algorithms and the availability of facial images in large database [2],[3]. This paper presents one such efficient algorithm to detect and identify the face in the given image. It needs a great effort to detect and identify the face in a clustered image as human face exhibits variations in the expression, skin color, hairstyle etc[4]-[6]. The proposed methodology uses Viola-Jones algorithm for face detection and Linear Discriminative Analysis and Artificial Neural Network for identifying the face detected.

The proposed methodology is implemented in two phases: First phase detect the face in the clustered image using Viola-Jones algorithm. The Viola-Jones algorithm extracts the features from the face and classifies these features using Adaboost classifier. The next phase identifies the face detected in the image using Linear Discriminative Analysis and Artificial Neural Network. The results obtained using these algorithms are more accurate in comparison with the existing methods. The proposed methodology uses BioID-face-database, which collects huge number facial images and can be used as standard image data base for the purpose of face detection and identification.

II. Related Work

Varsha Gupta et al.,[7] carried out a survey to categorize the detection methods on the basis of the object and motion representations used with thorough descriptions of representative methods in each category and look at their pros and cons. Siddarth Ravi et al.,[8] carried out a comparative study using the two important appearance based face recognition methods PCA and LDA. They are implemented and evaluated with different databases and compared using accuracy rate. Juwei Lu et al.,[9] proposed a new algorithm that deals with disadvantages of traditional LDA in an efficient and cost effective manner. The method is compared in terms of classification accuracy with the other commonly used FR methods and the results indicate a superior performance compared to other methods. Zhen Lei et al.,[10] proposed a novel and efficient feature selection method that is designed for LDA. Fisher criterion was used to select the most discriminative and appropriate features so that the face recognition performance is improved. Hyun-Chul Kim et al.,[11] proposed a new face recognition method, called LDA mixture model, that the set of all classes are partitioned in to several clusters and the transformation matrix for each cluster is obtained. This improved the classification performance greatly. Chu Zhang et al.,[12] proposed a novel Fisher criterion by using geometric distribution information of the training samples. The GLDA algorithm is then developed for face recognition. The proposed GLDA approach was evaluated with two available databases. Hazem M. El-Bakry et al.,[13] introduced a simple technique for identification of faces in cluttered scenes based on neural nets. Neural nets are used to test whether a window contains a face or not. The data was divided in to two groups to reduce computational complexity and thus

decreasing the time and memory needed during testing of an image. Feature measurements are made using fourier descriptors. Ming Zhang et al.,[14] presented a artificial neural network Group-based Tree model for face perspective understanding. NGT model offers significant improvement over conventional neural network trees for image understanding. Abhjeet sekhon et al.,[15] proposed back propagation based artificial neural network learning algorithm for recognizing human faces. Eight features were considered for recognition. The basic objective was to understand the ability of back propagation learning algorithms for face recognition task. Raman Bhati [16] proposed a way to achieve the optimum learning rate of the multi layer feed forward neural network. The PCA and Multilayer Feed Forward Network are applied in face recognition system. Variable learning rate is used over constant learning rate to realize this. Dhirender Sharma et al.,[17] proposed a two step modular architecture for improvised matching score. First step decomposes the facial image into three sub-images. Second stage solves sub-image redundantly by two different neural network models and feature extraction techniques. Two step integration is performed using probabilistic sum, min, max, product and polling integration techniques.

III. Proposed Methodology

The proposed paper presents an efficient algorithm for detecting and identifying the face in the given image by applying Viola-Jones algorithm, Linear Discriminative Analysis algorithm and Artificial Neural Network. The flow chart for proposed methodology is as shown in Fig.1.

In the proposed method, an image is selected from a readily available Bio-ID-Face-Database either in the form of color or grey scale. The initial step is to preprocess the image selected from the database. After preprocessing contrast stretching is performed on the image for making the pixels in the image more brighter

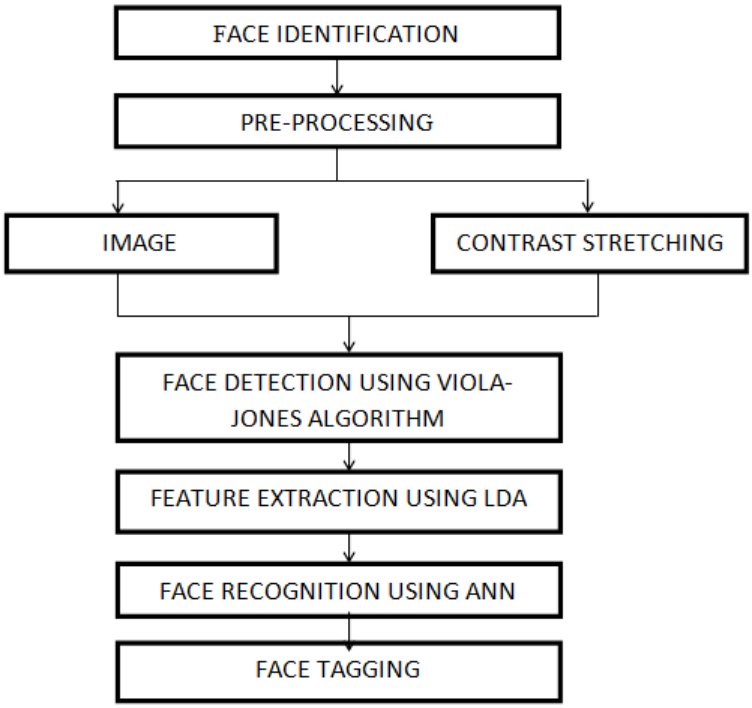

Fig.1: Flow chart for proposed methodology

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3.1 Face Detection

Viola-Jones algorithm is applied for finding the human face in the image. The Viola-Jones algorithm will detect the human face present in the image by calculating the Haar features. The various Haar features used in the Viola-Jones algorithm are as shown in the Fig.2. The Haar features varies in width and height. Based upon the value of sum of the black pixels and the white pixels various parts of the face like eyes, nose, cheek etc are identified. The Haar features are calculated on the total image and are large in number. Adaboost reduces the unwanted features. Based on these features the face is detected in the image and is resized to a desired standard resolution.

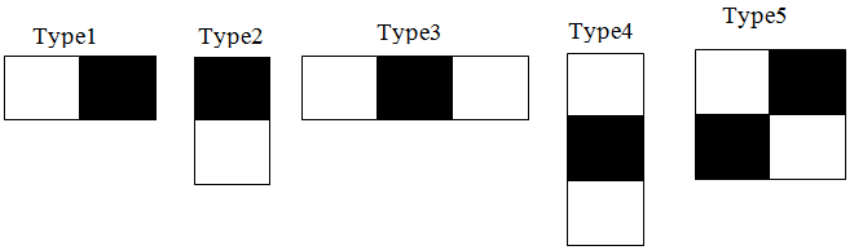

Fig 2: Haar features in Viola-Jones

3.2 Feature Extraction

Linear Discriminative Analysis is an efficient algorithm for face recognition as it encodes discriminatory information. If the applied inputs to the system are linearly separable LDA is a good classifier and when computational complexity is a challenge LDA is simple to implement. face recognition with LDA solves generalization and overwriting problems. Proposed method is implemented using subspace Linear Discriminative Analysis.

The feature dimension is restricted to around 400 even with face subspace projection. For example if the sample ratio is around 175 to 100, it creates a problem leading to typical dimensionality. The advantage of LDA is that it can be applied to cases such as pattern classifier. Scatter matrix analysis is carried out for training the LDA. Consider an M-class problem where Sw and Sb are scatter matrices. Sw and Sb are computed as follows:

$sw = \sum_{i=1}^{M} \Pr Ci \sum i$ (1)

$Sb = \sum_{i=1}^{M} \Pr Ci(mi - m0)(mi - m0)t$ (2)

Where Pr and Ci are the prior class probability. Assuming equal priors Sw is within the class scatter matrix giving the average scatter $\sum$ i .

$\sum i =$ E[(x-mi)(x-mi)t|C=Ci| (3)

In the same way if Sb is in between- class scatter matrix it can be represented in terms of the mean vector mi and overall mean vector m0. The generalized Eigen value is given by

Sb*W = Sw*W*Aw (4)

The linear discriminant functions for linear discriminative analysis:

Di(x) = Wt(x-mi) (5)

LDA is used in order to obtain a linear classifier in the subspace. The subspace dimension is chosen since it enables to generate class separable features through LDA from full subspace representation. Thus successfully solving generalization and overwriting problem that occurs in face recognition on huge database. The performance of the subspace LDA method can be improved by employing a weighted distance metric guided by the LDA Eigen values.

3.3 Face Recognition

The next step in the process is to identify the detected face using Artificial Neural Network. An Artificial neural network can be compared to a human brain system. The concept of Artificial Neural Network is to make the computer think like human brain. Neural network system has building blocks called as neurons and all the neurons are connected by a path to carry electric current referred to as synapses. An Artificial Neural Network has inputs, outputs and hidden cells shown in Fig.3.

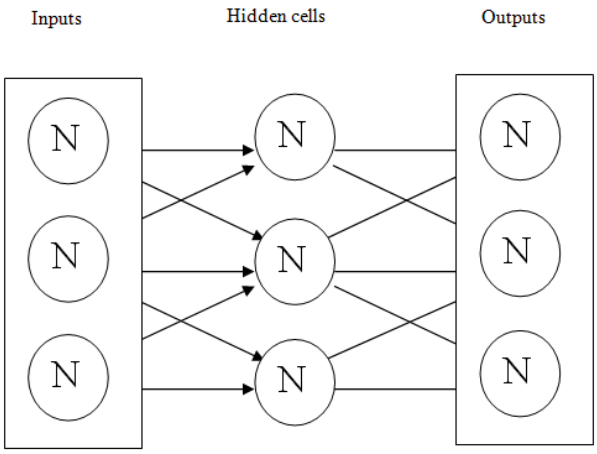

Fig.3: Artificial Neural Networks

The Neural Network finds the connection weights between the input, output and hidden cells through back propagation technique The Neural Networks learn through the back propagation technique and determine the connection weights between the inputs, outputs and hidden cells and the desired output is calculated. The back propagation uses the formula that has weights, inputs, outputs, error and learning rate to minimize the error.

3.4 Training of Neural Networks

For each individual in the database one ANN is used. Face descriptors are used as input for training of ANN. The face descriptors belonging to the same individual are used as positive examples for that individual network and as negative example for others. For identifying the individual trained network will be used.

3.5 Simulation of Neural Networks

All the networks are simulated with Face descriptors of the test image calculated from the Eigen faces as input. Maximum output greater than a predefined threshold level confirms that the test image belongs to the recognized person with the maximum output.

IV. Results And Analysis

Pre-processing is carried out on the image considered from the Bio ID-Face-Database. Contrast stretching is performed on the acquired image to make it more brighter. Viola-Jones algorithm is applied to the pre-processed image for detecting the face present in the image as shown in Fig.4.

Fig.4: Face identified by voila-jones algorithm (Red boundary).

The important features in the face are detected by the Viola-Jones algorithm and are highlighted by a bounding box as shown in Fig .5. This image is used in marking the corresponding nodes identified in the image as shown in Fig.6.

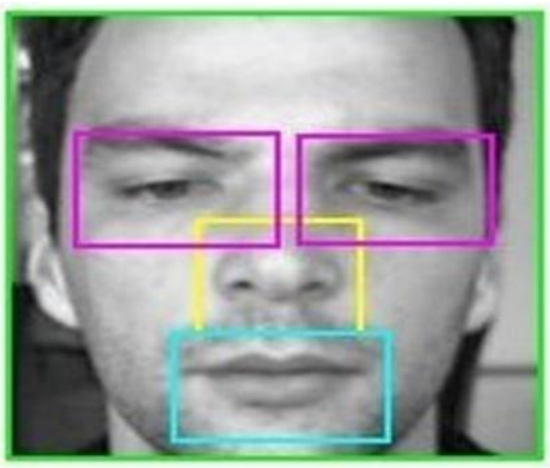

Fig.5: Face features (parts) identified by Voila-Jones algorithm (Boundary box).

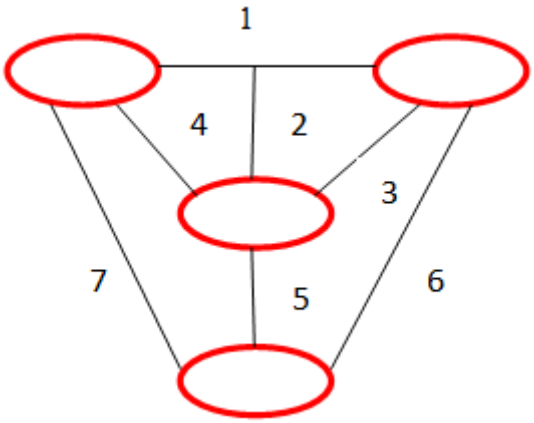

Fig.6: Face feature calculation

The features are calculated from various angles as shown in Fig. 6 and the details of the calculated features are tabulated as shown in Table 1. Based on the features calculated the detected person is identified.

Table 1: 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

Table 2: Results

Authors/Techniques	**Identification accuracy**
Kamencay P[18] [Using principal component analysis (PCA)]	90 %
Fernandez [19] [Viola-Jones Algorithm and Artificial Neural Networks]	88.64 %
Mohammad Da'san[20] [Viola-Jones Algorithm , Neural Networks]	90.31%
Proposed method [Viola-Jones Algorithm ,Artificial Neural Networks and LDA]	92%

The proposed method is compared with the other existing methods for identification accuracy as shown in Table 2. Face detection and recognition using PCA proposed by Kamencay P et al.,[18] has an accuracy of 90%.Face detection and recognition using Viola-Jones Algorithm and Artificial Neural Networks proposed by Fernandez et al.,[19] provided an accuracy of 88.64 %. Mohammad Da'san et al.,[20] proposed face detection and recognition using Viola-Jones Algorithm and Neural Networks with an accuracy of 90.31 %.The proposed method with fusion of ANN and LDA provided an identification accuracy of 92%. Thus the proposed method provides a better identification accuracy in comparison with the other existing methods.

V. Conclusion

Face recognition plays a vital role in many applications, which are crucial and integral part of life, and hence a high identification rate is desired. An efficient approach for face detection and recognition using Viola-Jones algorithm, fusion of ANN and LDA is proposed in this paper. A total success rate of 92% is realized with the proposed method and hence can be considered in comparison with existing methods.

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