

Face Detection and Recognition using Viola-Jones algorithm and Fusion of PCA and ANN

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Abstract

The human face is a complicated multidimensional visual model and hence it is very difficult to develop a computational model for recognizing it. The paper presents a methodology for recognizing the human face based on the features derived from the image. The proposed methodology is implemented in two stages. The first stage detects the human face in an image using Viola-Jones 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.

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 from 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.

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 outperformed 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 non linear 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 Faruque 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 has 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.

PROPOSED METHODOLOGY:

The proposed method implement 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.

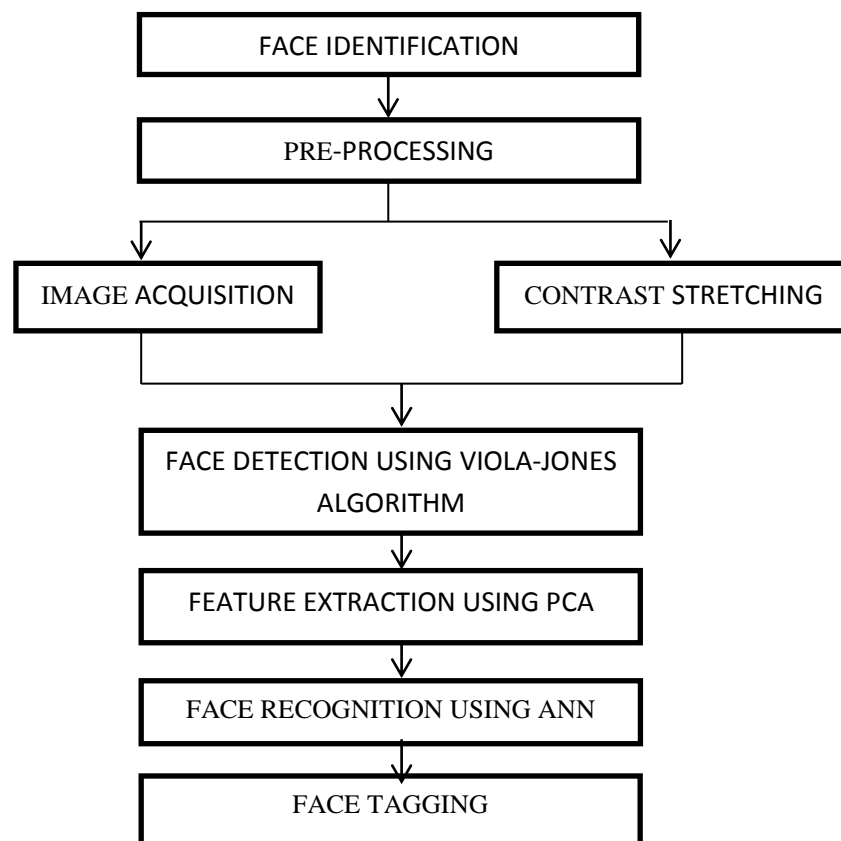


Figure 1: Flowchart of the proposed methodology

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.

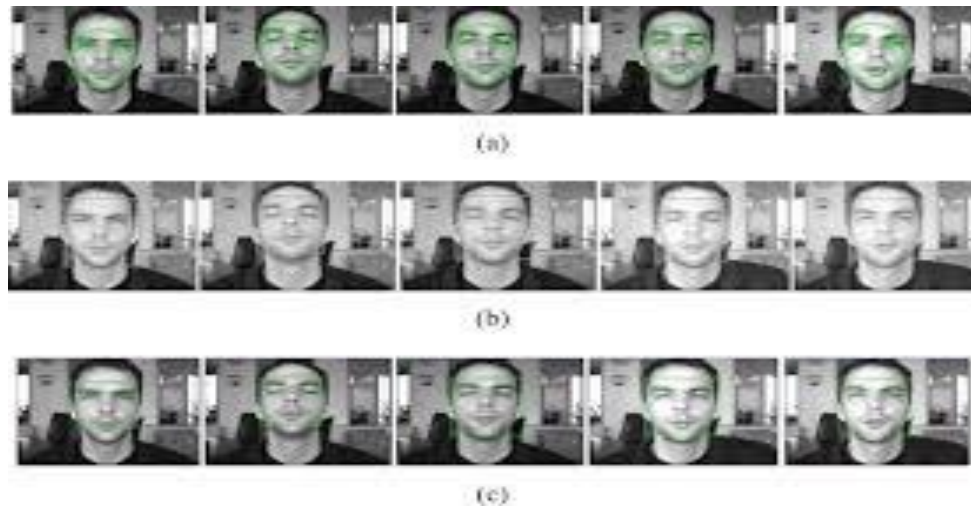


Figure 2: BioID Face Database

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.

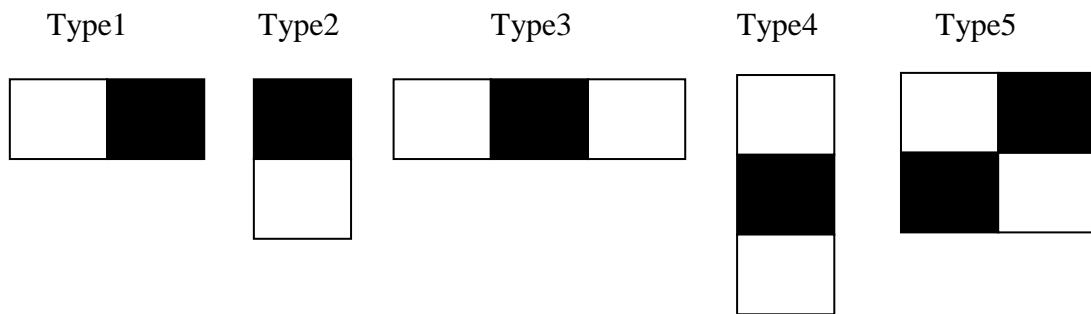


Figure3: Haar features in viola-Jones.

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.

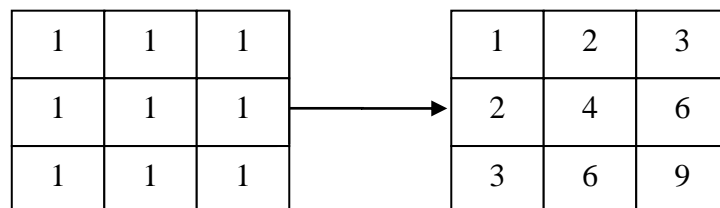


Figure 4: Integral image

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.

$$\text{Weak classifier} = \begin{cases} 1; \text{ Identified a feature (ex: nose)} \\ 0; \text{ Not Identified any feature (ex: no nose in image)} \end{cases}$$

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.

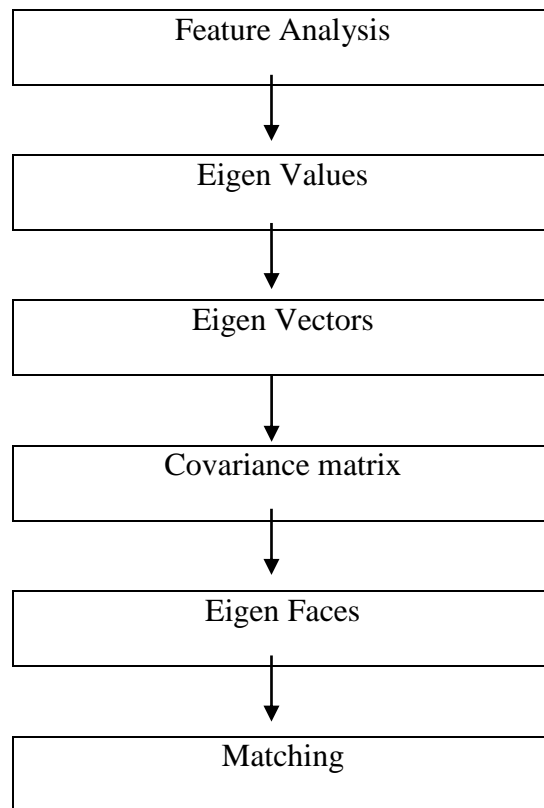


Figure 5: Flow chart of PCA Algorithm

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 $M \times M$ 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.

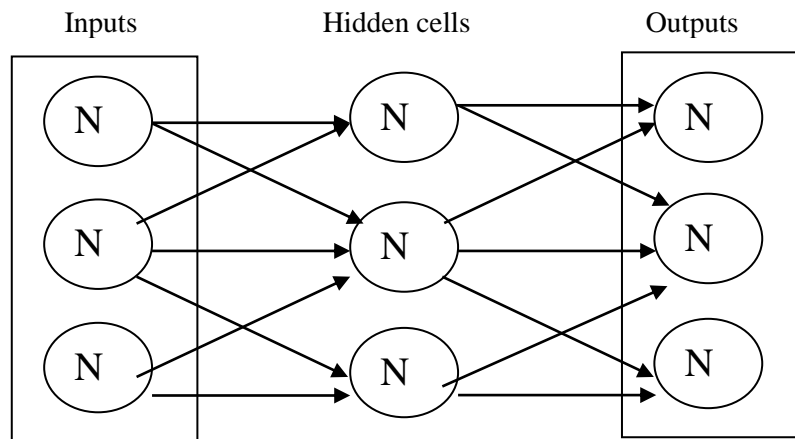


Figure 6: Artificial Neural Networks

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 $\text{output} = \text{input1} + \text{input2}$ 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.

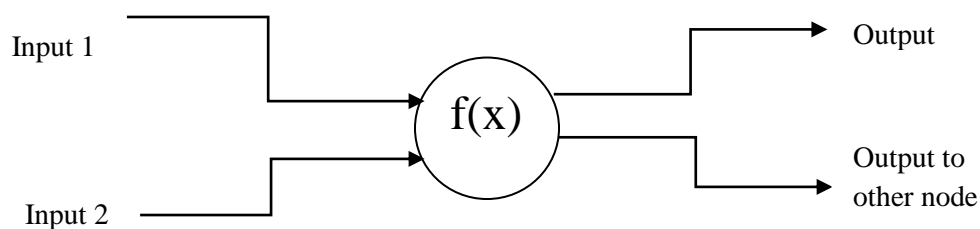


Figure 7: Individual neuron cell

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.

$$\text{Desired output} - \text{Calculated output} = \text{Difference error in network}$$

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".

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 Viola-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 Viola-Jones algorithm (Red boundary).

Main features of the face are identified by Viola-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.

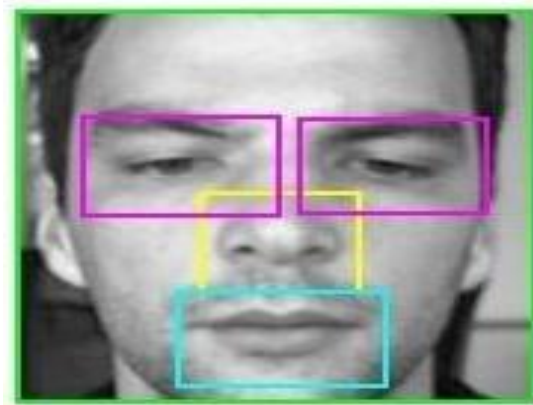


Figure 10: Face features (parts) identified by Viola-Jones algorithm (Boundary box).

The features extracted by Viola-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.

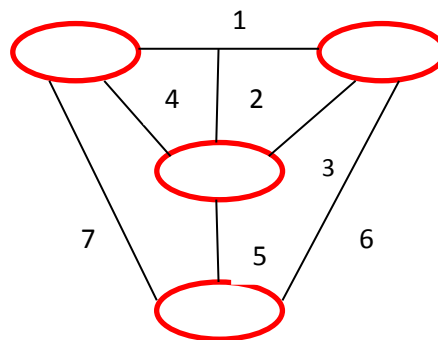
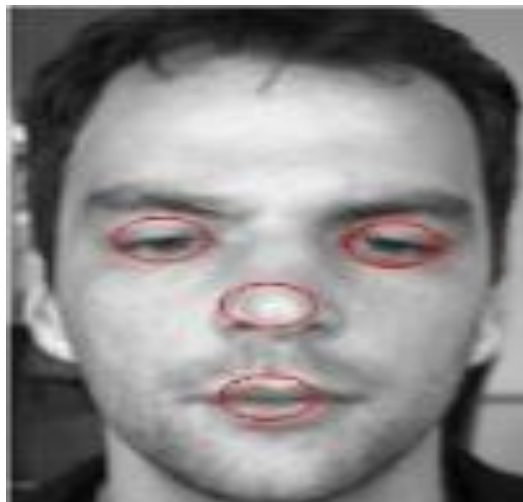


Figure 11: Face feature calculation

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

Table 2: Results

Authors/Techniques	Identification accuracy
PCA	72%
ANN	92 %
Kamencay P[28] a. Non segmented b. Segmented	84 % 90 %
Fernandez [29] [Viola-Jones Algorithm and Artificial Neural Networks]	88.64 %
Mohammad Da'san[30] [Viola-Jones Algorithm , Neural Networks]	90.31%
Proposed method [Viola-Jones Algorithm ,Artificial Neural Networks and PCA]	94%

The accuracy of face detection and recognition of the proposed method is compared with the existing methods as shown in Table 2. With PCA algorithm an image identification of 72% is realized and with ANN algorithm an image identification of 92% is achieved. Kamencay P et al.,[28] proposed face detection and recognition using PCA with an accuracy of 90%. Fernandez et al.,[29] proposed face detection and recognition using Viola-Jones Algorithm and Artificial Neural Networks with an accuracy of 88.64 %. Mohammad Da'san et al.,[30] 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 PCA provided an image identification of 94%. Thus the proposed method is more accurate in identifying a person in an image in comparison with the other methods.

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.

REFERENCES

- [1]. Janarthany Nagendrajah, "Recognition of Expression Variant Faces- A Principle Component Analysis Based Approach for Access Control" IEEE International Conference On Information Theory and Information Security, pp 125-129,2010.
- [2]. Maria De Marsico, Michele Nappi, Daniel Riccio and Harry Wechsler, "Robust Face Recognition for Uncontrolled Pose and Illumination Changes" IEEE Transaction on Systems, Man and Cybernetics, vol.43,No.1,Jan 2013.
- [3]. Shaoxin Li,Xin Liu, Xiujuan Chai, Haihong Zhang, Shihong Lao and Shiguang Shan, "Maximal Likelihood Correspondence Estimation for Face Recognition Across Pose" IEEE Transaction on Image Processing, Vol.23, No.10, Oct 2014.
- [4]. Jyothi S Nayak and Indramma M, "Efficient Face Recognition with Compensation for Aging Variations" IEEE International Conference On Advanced Computing, pp 1-5, Dec2012.
- [5]. Shermina J, "Illumination Invariant Face Recognition using Discrete Cosine Transform and Principal Component Analysis", IEEE International Conference On Emerging trends in Electrical Computer Technology, pp 826-830,2011.
- [6]. Anil K. Jain, "Face Recognition: Some Challenges in Forensics", IEEE International Conference On Automatic Face and Gesture Recognition, pp 726-733,2011.
- [7]. Ming Zhang and John Fulcher "Face Perspective Understanding Using Artificial Neural Network Group Based Tree", IEEE International Conference On Image Processing, Vol.3, pp 475-478, 1996.
- [8]. Hazem M. EI-Bakry and Mohy A. Abo Elsoud "Human Face Recognition Using Neural Networks" 16th national radio science conference, Ain Shams University, Feb. 23-25, 1999.
- [9]. Tahia Fahrin Karim, Molla Shahadat Lipu, Md.Lushanur Rahman, Faria Sultana, "Face Recognition using PCA Based Method", IEEE International Conference On Advanced Management Science, vol.13, pp 158-162, 2010.
- [10]. Muhammad Murtaza Khan, Muhammad Yonus Javed and Muhammad Almas Anjum, "Face Recognition using Sub-Holistic PCA", IEEE International Conference On Information and Communication Technology, pp 152-157, 2005.
- [11]. Patrik Kamencay,Dominik Jelsovka, Martina Zachariasova, "The Impact of Segmentation on Face Recognition using the PCA", IEEE International Conference On Signal Processing Algorithm, Architecture, Arrangements and Application, pp1-4, 2011.

- [12]. Hala M. Ebied, “ Feature Extraction using PCA and Kernel-PCA for Face Recognition”, IEEE International Conference on Informatics and systems, pp 72-77, May 2012.
- [13]. Patrik Kamencay, Martin Breznan, Dominik Jelsovka, Martina Zachariasova, “ Improved Face Recognition Method based on Segmentation Algorithm using SIFT-PCA”, IEEE International Conference On Tele communication and Signal Processing, pp 758-762, 2012.
- [14]. Rammohan Mallipeddi and Minhoo Lee , “ Ensemble Based Face Recognition using Discriminant PCA Features” IEEE International Conference On Computational Intelligence, pp 1-7, June 2012.
- [15]. Swarup Kumar Dandpat and Sukadev Meher, “ Performance Improvement for Face Recognition using PCA and Two Dimensional PCA”, IEEE International Conference On Computer Communication and Informatics, pp 1-5, Jan 2013.
- [16]. Firoz Mahmud, Md. Enamul Haque, Syed Tauhid Zuhori and Biprodip Pal, “ Human Face Recognition using PCA based Genetic Algorithm”, IEEE International Conference On Information and Communication Technology, pp 1-5, 2014.
- [17]. Muhmmad A U Khan, Muhmmad Khalid Khan, Muhammad Aurngzeb Khan, “ Improved PCA based Face Recognition using Directional Filter Bank”, IEEE International Multi topic Conference, pp 118-124, 2004.
- [18]. Jia-Zhong He, Quig-Huan Zhu, Ming-Hui Du, “ Face Recognition using PCA and Enhanced Image for Single Training Images”, IEEE International Conference On Machine Learning and Cybernetics, Aug 2006.
- [19]. Akrouf Samir and Youssef Chahir, “Face Recognition Using PCA and DCT”, IEEE International Conference On MEMS NANO and Smart systems, pp 15-19, 2009.
- [20]. Md. Omar Faruqe and Md. Al Mehedi Hassan, “Face Recognition Using PCA and SVM”, IEEE International Conference On Anti-Counterfeiting, Security and Identification in Communication, pp 97-101, 2009.
- [21]. Girish G N, Shrinivasa Naika C L and Pradip K Das, “Face Recognition Using MB-LBP and PCA: A Comparative Study”, IEEE International Conference On Computer Communication and Informatics, pp 1-6, Jan 2014.
- [22]. S Ravi, Dattatreya P Mankamane and Sadique Nayeem, “Face Recognition Using PCA and LDA: Analysis and Comparison”, IEEE International Conference on Advances in recent Technology in Communication and Computing, pp 6-16, 2013.
- [23]. Abhjeet Sekhon and Pankaj Agarwal, “Face Recognition Using Back Propagation Neural Network Technique”, IEEE International Conference on Advances in Computer Engineering and Applications, pp 226-230, 2015.
- [24] HayetBoughrara, Mohamed Chtourou, Chokri Ben Ama and Liming Chen “MLP Neural Network Using Modified Constructive Training Algorithm: Application to Face Recognition” IEEE Ipas’14: International Image Processing Applications And Systems Conference, 2014.

- [25] Mitsuharu Matsumoto, "Cognition Based Contrast Adjustment using Neural Network Based Face Recognition" IEEE International Conference on Industrial Electronics, pp 3590-3594, 2010.
- [26] Raman Bhati "Face Recognition system using multi-layer feed forward Neural Networks and principal component analysis with variable learning rate", IEEE International Conference on Communication Control and Computing Technologies, pp 719-724, 2010.
- [27] Dhirender Sharma and JoydipDhar, "Face Recognition using Modular Neural Networks", IEEE International Conference on Software Technology and Engineering , 2010.
- [28] Kamencay, P, Jelsovka, D.; Zachariasova, M., "The impact of segmentation on face recognition using the principal component analysis (PCA)," IEEE International Conference in Signal Processing Algorithms, Architectures, Arrangements, and Applications, pp.1-4, Sept. 2011.
- [29] Ma. Christina D. Fernandez, Kristina Joyce E. Gob, Aubrey Rose M. Leonidas, Ron Jason J. Ravara, Argel A. Bandala and Elmer P. Dadios "Simultaneous Face Detection and Recognition using Viola-Jones Algorithm and Artificial Neural Networks for Identity Verification" , pp 672-676, 2014 IEEE Region 10 Symposium, 2014.
- [30] Mohammad Da'san, Amin Alqudah and Olivier Debeir, " Face Detection using Viola and Jones Method and Neural Networks" IEEE International Conference on Information and Communication Technology Research , pp 40-43,2015.

