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Analysis and Design of Principal Component Analysis and Hidden Markov Model for face recognition

Dinesh Kumar. D. S[a*], P. V. Rao[b]

[a]*Ph.D Research Scholor, TJIT, VTU Belgaum*

[b]*Prof and R&D Head, Dept.of ECE, Rajarajeswari College of Engineering, Bangalore*

Abstract

Biometric detection is considered as an important tool for states to use to strengthen the safety measures. Biometric increases robustness of the biometric system against many attacks and solve the problem of non-universality. Since facial image is the mandatory biometric identifier this proposed work focuses on the use of facial image. Face authentication involves extracting characteristics set such as eyes, nose, mouth from a two dimensional image of the user face and matching it with the templates stored in the database. Facial recognition is a difficult task because of the fact that the face is variable social organ which displays a variety of expressions. The proposed method is for facial recognition for both images and moving video using Principal Component Analysis (PCA), includes Hidden Markov Model (HMM) technique and Gaussian mixture model (GMM) and Artificial Neural Network (ANN), Since HMM technique is a powerful tool for statistical natural image processing and videos. PCA is a statistical procedure which uses an orthogonal transformation. Face recognition techniques dependent on parameters like background noise, lighting, eyes moments, lips and position of key features. Moreover, the face patterns are divided into numerous small scale states and recombined to obtain the recognition result. The experimental results are obtained from this proposed work has been achieved the performance parameters 99.83% of false rejection rate (FRR) and 0.62% of false acceptance rate (FAR) and an accuracy of 96% is implemented using Matlab2012A.

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* Corresponding author. Tel.: +91-8722497866, +91-9880994563.
E-mail address: *dineshphd2014@gmail.com, raopachara@gmail.com*

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1. Introduction

Automatic verification and identification of a person from a digital image or video frame from a video source is done by facial recognition system. Here, in this work the facial features are selected and compare these features with the data base collected. Facial recognition system is similar to other biometrics such as fingerprinting, iris recognition and many others. Some facial recognition algorithms extract some features of the face and matches with the features of the image that are stored in the data base. There are many recognition algorithms which include PCA using Eigen faces, linear discriminate analysis, elastic bunch, Hidden Markov Model and many others. In this paper ,it exploits principal component analysis (PCA) algorithm with Hidden Markov model.

2. Related Work

S.Palanivel and B.Yegnanaraya, proposed a method on automatic multimodal person authentication system which uses motion information to locate face region and location of eyes is also determined. This method produces an equal error rate of about 0.45%for 50 subjects [5]. Eshwarappa .M.N and Dr. Mrityunjaya.V.Latte, proposed the fusion of many biometrics. The results showed 100% identification and verification performance and produces a FAR and FRR of 0% [4]. G. Prabhu Teja and S. Ravi proposed pre-processing techniques and subspace methods for recognition. This method needs less memory requirements, lowest EER [6]. Faten Bellakhdhar, Kais Lonkill and Mohamed Abid, proposed a new method by combining phase and magnitude of Gabor's representation of face. PCA and SVM algorithm is also used for recognition of pattern. The results with an better recognition rate of 99.9% [1]. Mahesh.P.K. and M.N. Shanmukhaswamy, proposed a biometric system for speech signal and palmprint identity verification and this gives an accuracy of 98.63% with FAR of 1.07% and FRR of 0.84%[7]. Conrad Sanderson and Kuldip.K.Paliwal, proposed a method which measures the quality of speech signal independent identity verification system. They also proposed Eigen faces approaches and also describes about many speech feature extraction techniques [8]. Sangeeta Karkarwal and Ratnadeep Deshmukh, proposed wavelet transformed based analysis method for facial recognition based on Wavelet Transform. The result shows the output performance of correlation and threshholding [2]. Changhan Park and Joonki Paik, extracts the features of speech and face using PCA and HMM algorithm. The disadvantages of a single mode system were eliminated and FRR is reduced to 0.0001% [3].

3. Problem Statement

The most frequent biometric trait used by human for the recognition of individual is the facial image, which finds many applications in biometric technology. There are many methods proposed for face recognition system which detects face, signatures, speech and eyes; and in this paper by using an improved methodology of PCA including HMM which not only recognize face but also various parts of face like mouth, nose and eyes which are stored in the database [11]. The proposed work obtains the performance factors FRR of 99.83% and FAR of 0.627%, is used for the identification of separate organs like head, face, mouth, eyes and nose.

4. Methodology

Fig.1. shows the overall block diagram of proposed method. It consists of following blocks facial image database, image pre-processing, principal component analysis (PCA), Hidden Markov model (HMM), Gaussian Mixture model (GMM) and Artificial Neural Network (ANN).

4.1. Facial Image Database

The facial images from different sources such as videos and still images are collected and stored in the database

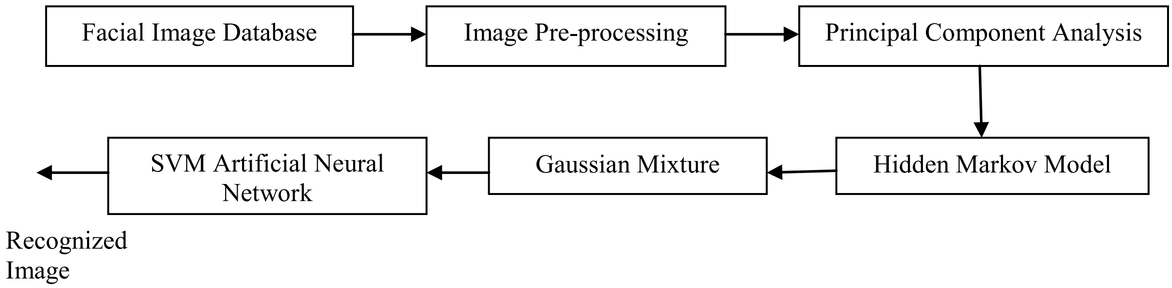


Fig.1. Block diagram of proposed work for identification of facial organs

4.2 Image Pre-processing

The preliminary step for face detection is the Image Pre-processing. The image is to be matched with the image stored in the database after pre-processing test. The pre-processing module consists of

A. Smoothing and Sharpening
B. Contrast Enhancement

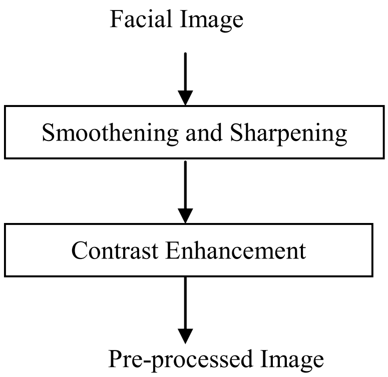


Fig.2 Pre-processing of facial image

A. Smoothening and Sharpening

The wiener filter is used to get the optimal resolution in spatial and frequency domains. The degree of smoothening can be adjusted by varying the standard deviation of wiener filter [12].

B. Contrast Enhancement

Histogram Equalization is applied to the whole face image or part of image to improve the contrast and to get uniform intensity. The intensity of the image is enhanced by transforming the values in an intensity image and compares with the specified histogram. Here the output obtained is in symmetric with the input. After increasing the intensity of the image; the face portion has to be exactly located in the input image. This is achieved by employing template matching with various dimensions of several faces of the image [8]. The affine transformation [7] is used to find the distance between the two eyes is same for every person to detect nose and mouth.

5. Principal Component Analysis

Principal Component Analysis (PCA) uses an orthogonal transformation which is a statistical procedure to convert a set of observations of possibly correlated variables into linearly uncorrelated set of values [13]. The Eigen vectors of the face are extracted from PCA. Eigen vector extracts many features of the face when the Eigen value is high [1]. For pose estimation of PCA covariance matrix C and its Eigen vectors from the training set are computed. Let us consider N training face vectors Z_1, Z_2, Z3.........Z_N. By definition C can be estimated as [3].

$$C = E[ZZ^k] = \frac{1}{N}\sum_{k=1}^{N} Z_k Z_k^T \text{ --------(1)}$$

The training data sets are packed into following matrix.

$$Z = [Z_1, Z_2 \ldots\ldots\ldots\ldots Z_N] \qquad \ldots\ldots\ldots\ldots\ldots \quad (2)$$

The Eigen vectors of ZZ^T are to be estimated. From the fundamentals of linear algebra the Eigen vectors of ZZ^T can be calculated from Eigen vectors of Z^TZ. Suppose the rank of Z is r , r≤N. then

$$Z = \sum_{k=1}^{r} \sqrt{\lambda_k}\, U_k V_k^T \text{ --------(3)}$$

Where $\sqrt{\lambda}$, U_k and V_k respectively represent singular values; the left and the right singular vectors of Z, U_k and V_k have the following relationship.

$$U_k = \frac{1}{\sqrt{\lambda}} Z V_k$$

Hence, the Eigen face value U_k is obtained from V_k. Recognized face classified using eq-(4)

$$d = \sum_{i=1}^{m} (r_i - t_i)^2 \text{ ------(4)}$$

Where r_i and t_i represent input pattern and pattern of train respectively.
If there is any large variation in the detected image is to be retained and applied to the next stage.

6. Hidden Markov Model

HMM is used for statistical natural image processing as a powerful tool. In many biological sequence HMM are widely used .It is used to analyze many problems such as multiple sequence alignment, classification, searching of similarities and many others. Fig. 3 shows the architecture of HMM [14].

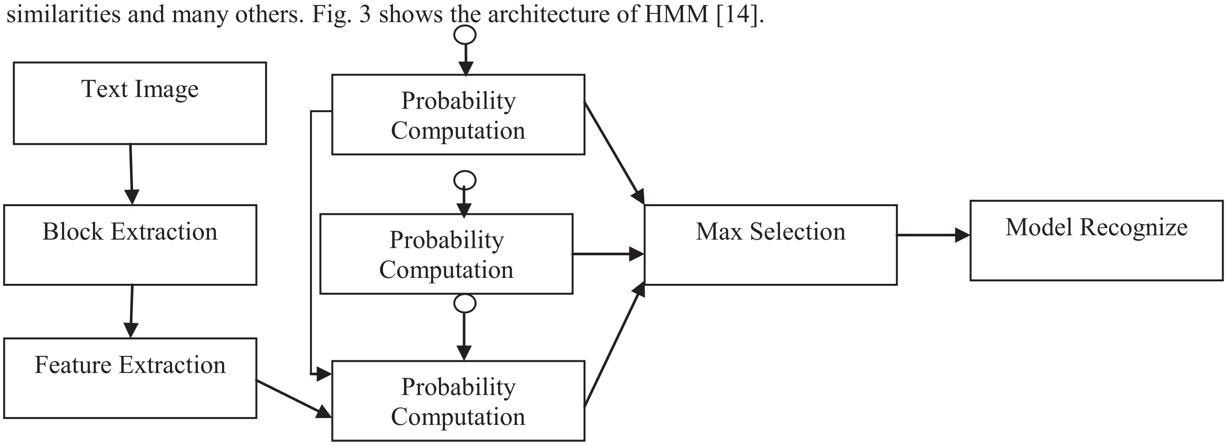


Fig.3. Architecture of HMM

HMM models correlation between different event applications in many domains, adjacent symbols and serves applications in many fields such as digital communication, speech recognition etc. Here, the probabilities of transition of the state are only the parameter for HMM. This model gives information of the output of the stage on which it dependant .It generates a token and gives the information about the sequence of the stages [15]. Hidden Markov Model is a mixture model where the variables are hidden and are controlled by the mixture components which are selected for each and every observation that are related in Markov process and independent of each other. Fig.4. Show the general architecture of an instantiated HMM. In Fig.4, the oval shape is the random variable, and it can take any number of values.

m (t) =Hidden state at t.

m (t) $\in \{m_1,m_2,m_3\}$.

n (t) = observation time t.

n (t) $\in \{n_1,n_2,n_3\}$

m1, m2, m3 and n1, n2, n3 are a set of hidden state values and observation times respectively

Arrows denotes that dependencies are conditional.

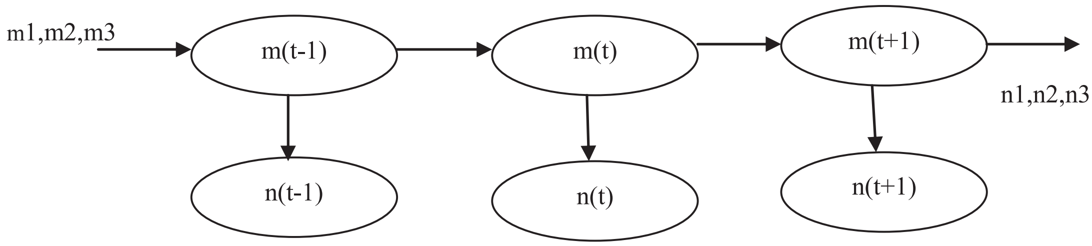


Fig.4. General Architecture of an Instantiated HMM

7. Gaussian Mixture Model (GMM)

At a given hidden variable time m (t) the hidden variable m depends only on the hidden variable (t-1) this is called Markov property. Hidden Markov property has two parameters namely transition probability and emission probability. GMM is the sum of densities of Gaussian components. Since, the expression in the human face will be changing according to the situation detecting or understanding it is difficult. Therefore, Gaussian mixture model is used to find out invariant face recognition. This method is used to characterize human faces and find out variations in the faces with different mixture components. These mixture components learn from the trained data present in the mixture model. GMM is a powerful algorithm and ability to smoothen arbitrarily shaped densities. Gaussian mixture distribution function consists of one or more multivariate Gaussian distribution components.

GMM consists of following components which is a step by step model or ordered model

1. The observations consist of N random variables which are distributed according to K components and belong to the same family of distribution.
2. Latent Variables specifies the identity of the mixture component corresponds to the N random variables and is distributed according to K dimensional distribution.
3. A set of K mixtures weight is having the probability whose sum is equal to 1.
4. Each component in the distribution has a mean and variance. According to V-dimensional distributions the observations are distributed.

8. Artificial Neural Network

Artificial Neural Network consists of many simple processors which are called neurons. These are similar to biological neurons in brain. Fig.5 shows the architecture of support vector machine (SVM) artificial neural networks. The signals are passed from one neuron to another by weighted links. The neurons outgoing connection transmits the output signals [19]. This connection splits into number of branches which will transmit similar signals out of many similar input neurons one will be selected and transmitted as the output. The incoming connections are then transmitted by outgoing connections. These networks are used to eliminate the problem of selection of dissimilar input neurons. The main goal of ANN is to learn from the trained data set. These networks use many learning rules. Whenever there is uncertainty in the data functions these networks are used [18]. The application of ANN involves in many fields such as credit and policy approval, pattern recognition classification, fraud detection and many others.

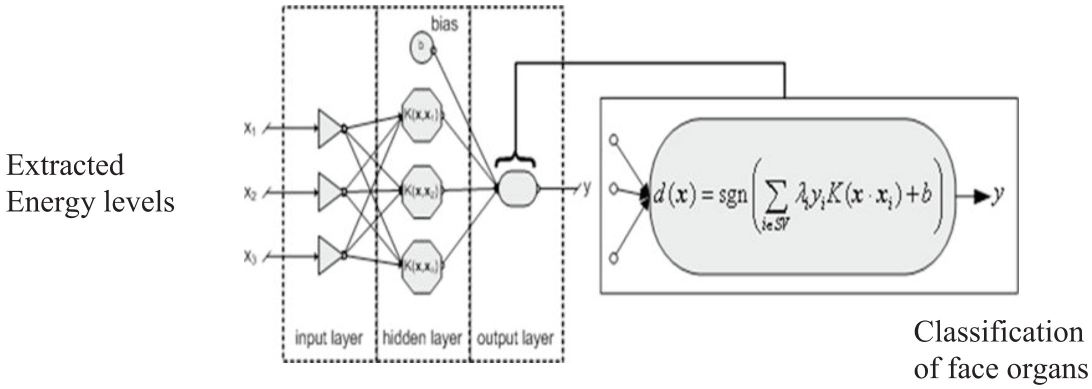


Fig.5. Architecture of Artificial Neural Network

For classification perceptron is the set with target t for a given input set. The perceptron weight change by a factor Δw, if the output is not equal to target value.

9. Implementation and Results

The implementation is done using Matlab 2012A. A Graphical User Interface is created and is as shown in Fig.6. The face image is collected from different sources. This image is to analyze by selected through the GUI. The selected image is smoothened and sharpened using wiener filter, and then applied to the histogram equalizer to increase the contrast of the image. From the experimental results by this method the performance factors are improved FRR to 99.8%, FAR 0.672% and the accuracy to 96%.

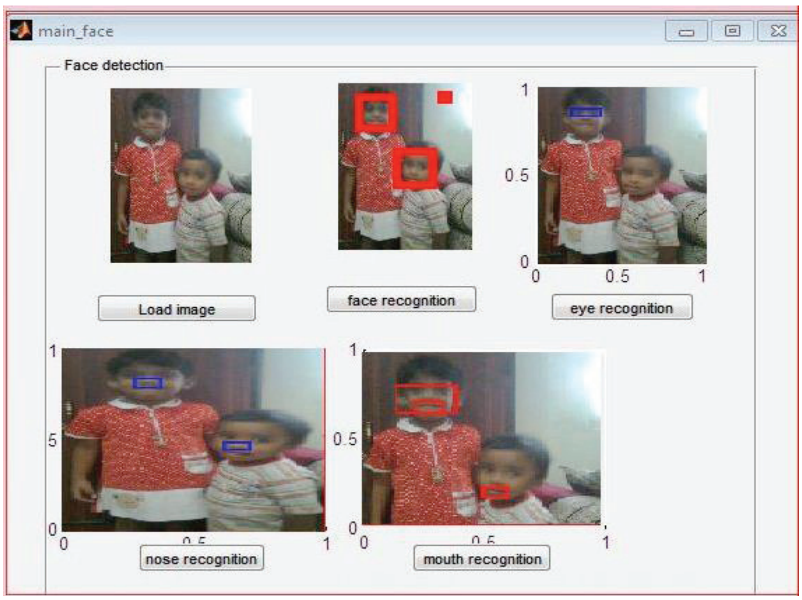


Fig.6.GUI for Face Recognition

In Fig.7 first from the database of the collected images, one image is loaded through the GUI. The loaded image is pre-processed and is shown in GUI to increase the intensity and sharpens the image. The enhanced image is then applied to the principal component analysis (PCA) which removes the noise. The noiseless is then applied to HMM which solves the problem of classification and searching similarities. GMM is used to find out invariant faces. Finally the image is applied to algorithm for detection of face is shown in Fig.7. ANN which corrects error and classifies face organs into face, mouth, eyes and nose images based on the similarities of the image stored in database.

In this work, proposed four algorithms for various parts of face recognition and analyzed simulated for performance improvement from the existing 50 images obtained from data base. Fig.7 shows GUI for the identification of face detection of facial organs. Fig.8 shows GUI for the identification of eyes detection. Fig.9 shows GUI for the identification of nose detection. Fig.10 shows GUI for the identification of mouth detection. Fig.11 shows the analysis report for the measurement of FAR. Fig. 12 shows the analysis report for the measurement of FRR. Fig.13 shows recognition of multiple facial organ detection. Table1 shows the performance parameters FRR and FAR comparison of three previous research paper results with current proposed work.

Fig.7. Face Recognition from GUI

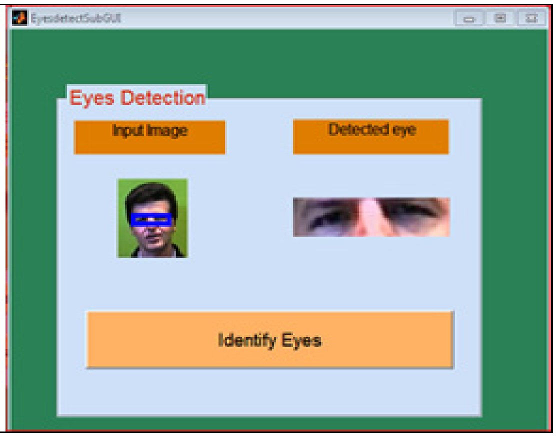


Fig.8. Eyes Recognition from GUI

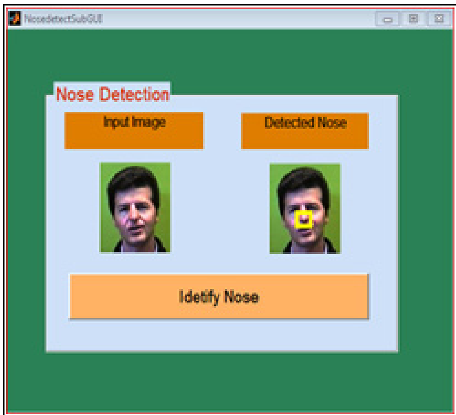


Fig.9. Nose Recognition from GUI

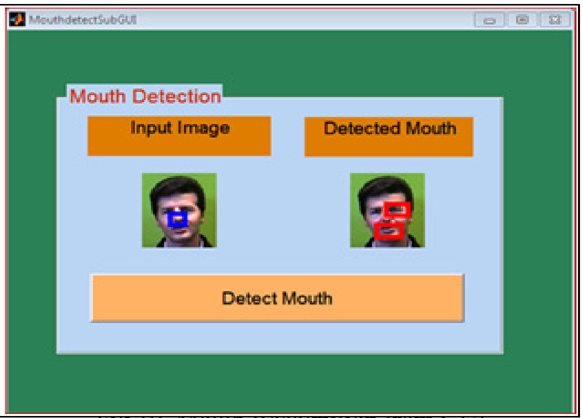
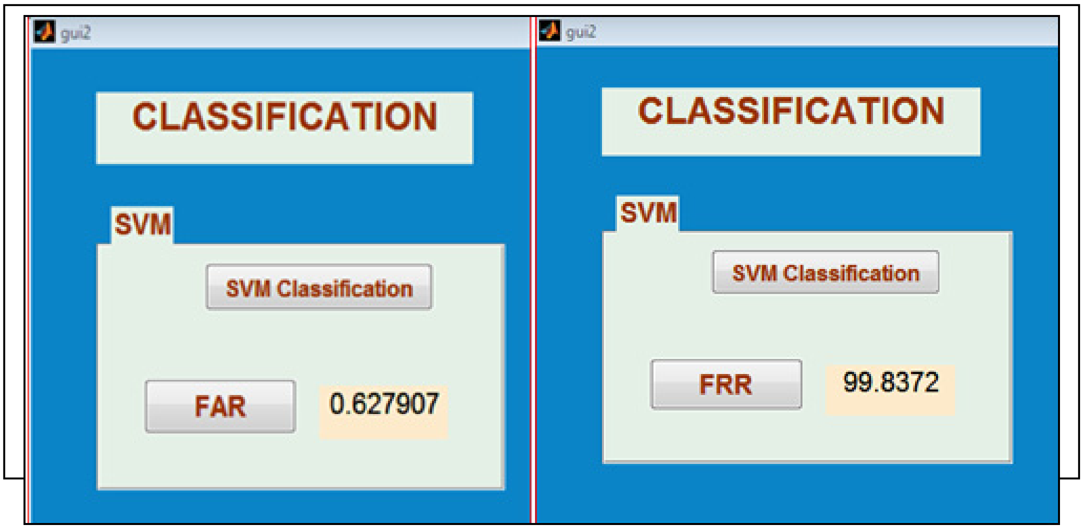


Fig.10. Mouth Recognition from GUI



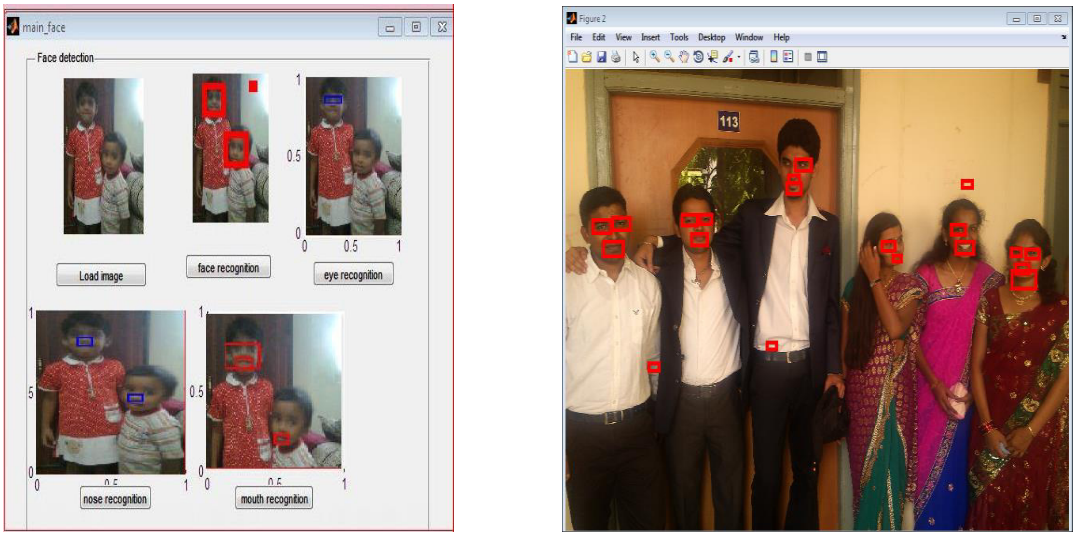


Fig.13. Recogintion of multiple facial organ detection

Table 1 Performance Comparison of FRR and FAR results

Author	FRR (%)	FAR (%)
S. Palanivel	-	0.45
Eshwarappa	97.7	0
Faten Bellakhdhar	98.63	1.07
Proposed method	99.83	.62

10. Conclusion and Future Work

In this paper we have proposed a multimodal face recognition system with four different algorithms are Principal Component Analysis, HMM, GMM and SVM-ANN and analyzed individually. It is simulated for better performance comparison in terms of FRR, FAR and accuracy for the various parts of human body like face, eyes, nose and mouth. PCA retains the tested image if there is a large variation and then gives to the hidden Markow model for searching of similarities and to reduce the noise in the image. SVM is used for organ classification. From the existing 50 images in the database, the output of 48 images are analyzed, simulated and compared for performance analysis. From the experimental results the proposed method achieved FRR of 99.83%, FAR of 0.672% and an accuracy of 96%. In future, this can be implemented on VLSI by using Field Programmable Gate Array for real time face recognition applications.

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