ISSN:0975-9646

V.Ramaswamy et al, / (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 5 (6) , 2014, 7972-7976

3D Face Detection and Recognition under Occlusion

Dr.V.Ramaswamy[1], Parashuram Baraki[2]

[1] *Research Guide, Jain University, Bangalore,*
[2] *Doctoral Student, Jain University, Bangalore*
& Asst.Professor , CS&E, Dept,
GM Institute of Technology, Davanagere

Abstract: Human face is undoubtedly one of the most deserving biometric an aspect for which automatic authentication is very vital. Three-dimensional face recognition exploits facial surface information. Compared to 2D face recognition, 3D exhibits good robustness and high fake resistance. This makes it a good candidate to be used in high security areas. Face recognition is sensitive to aspects such as variation, illumination and occlusion. However, dealing with occlusions covering the facial surface is a great challenge which should be handled in such a way as to enable applicability to fully automatic security systems. In this paper, we propose an automatic 3D face detection and recognition system which is robust to occlusions. We basically consider two problems namely occlusion handling for surface registration and recognition with missing data. Face can be detected by using Viola Jones technique. Registration scheme makes use of Iterative Closest Point technique. Principal Component Analysis is being used to deal with recognition of face. Experimental results confirm that proposed techniques offer an occlusion robust face detection and recognition system.

***Index Terms-* 3D face, Iterative closest point, viola Jones, Principal Component Analysis**

I. INTRODUCTION

Biometric is an automated method of recognizing a person based on a physiological or behavioural characteristic. Biometric technologies are becoming the foundation of an extensive array of highly secure identification and personal verification solutions. As the level of security breaches and transaction fraud increases, the need for highly secure identification and personal verification technologies is becoming very relevant. Biometric based solutions provide confidential financial transactions and personal data privacy.

From a biometric point of view, human face is widely preferred because of several advantages: Due to its contactless acquisition, it is well accepted among users. Furthermore, its applicability to non-cooperative scenarios makes it suitable for a range of applications such as surveillance systems. The factors that degrade the performance of a face recognizer include presence of illumination differences, in-depth pose variations, facial expression variations besides the presence of occlusions. Two kinds of errors are being considered by a biometric system. They are false rejection – a legitimate user is rejected and false acceptance – an impostor is accepted as a legitimate user.

Face detection and recognition requires a digital camera to develop a facial image of the user for authentication. It is evident that identification is technically more challenging and costly. Identification accuracy generally decreases as the size of the database grows. Before the user can be successfully recognized by the system, he/she must be registered with the biometric system. User's biometric data is captured, processed and stored. As the quality of this stored biometric data is very crucial for further authentications, often several (usually 3 or 5) biometric samples are used to create user's master template. The process of the user's registration with the biometric system is called enrolment.

II. RELATED WORK

Developments in 3-D sensor technologies have increased interest in 3-D face recognition. In [1], it is shown that by using 3-D face, it is possible to obtain competitive results when compared to other areas such as iris and high-resolution 2-D facial images. A thorough survey of previously proposed 3-D face recognition systems can be found in [1]. In this section, we focus on the recent face recognition approaches which deal with realistic occlusion variations in 3-D.

In the studies using 3-D facial data, only a few consider facial occlusion detection, removal, restoration and missing data handling. In [11], author has proposed a method to detect occlusions by analyzing the difference between an original face and its approximation using Eigen face approach. The regions detected as occlusions are removed and the locations of the missing parts are employed in the restoration process which is handled by Gappy PCA [7]. In [3], a part-based method is proposed in which facial regions are aligned independently to average regional models. Regional division scheme is also employed in the classification stage where various regional classification results are fused with different fusion techniques. Experimental results indicate performance improvement by part-based system both for expression and occlusion variations. In [6], authors have proposed a nose-based registration scheme for better handling of occluded faces. Curvature information is utilized for automatic detection of nose area and an average nose model through Iterative Closest Point (ICP) algorithm is used for fine alignment. On the registered surfaces, occlusions are detected by analyzing the difference from the average face model.

Occlusion removal takes place using a modified version of PCA method. Restored faces are classified using different local masks and multiple classifiers are fused for final identity estimation.

III. PROPOSED SYSTEM

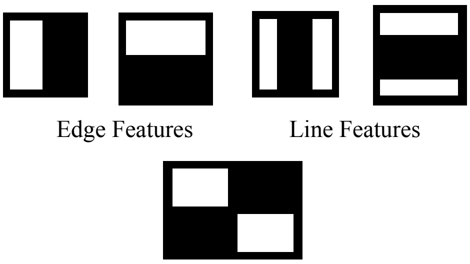
Our work introduces a method which can recognize a face under occlusion. We use three stages. First stage is the Face detection stage. Second stage is face registration and the third stage is face recognition which is based on features extracted from face.

The input to the proposed system is a video stream which considers only face surface and the output is detection and recognition of the face. We can define this face recognition system as a 3 step process as shown in Fig.1.

Fig.1:Face Detection and Recognition System

A. *Face Detection*

Face detection can be done using Viola-Jones detection technique. This technique contains three main ideas that build a successful face detector which runs in real time. They are the Haar-like features, classifier learning with AdaBoost, and the attention cascade structure. The technique relies on the use of simple Haar-like features as shown in Fig.2 that can be evaluated quickly through the use of a new image representation. Based on the concept of an “Integral Image”, a large set of features is generated. The boosting algorithm AdaBoost is used to select few Haar-like features from a larger set. They are then transformed into a suitable classifier. Cascade Classifier offers a method for combining simple to complex AdaBoost classifiers which enables background regions of image to be discarded by primary classifiers.



Four-Rectangle Features

Fig 2: Haar Features

B. *Face Registration*

Any camera (with sufficient resolution) can be used to obtain the image of the face during registration stage. Any scanned picture can be used as well. Generally speaking, the better the image source (i.e. camera or scanner) the more accurate results we get. The lighting conditions required are mainly dependent on the quality of the camera used. In poor light condition, individual features may not be easily discernible. There exist even infrared cameras that can be used with facial recognition systems.

Most of facial recognition systems require the user to stand at a specific distance away from the camera and look straight at the camera. This ensures that the captured image of the face is within a specific size tolerance and keeps the features (e.g., the eyes) in as similar position each time as possible.

Iterative Closest Point (ICP) algorithm [8] is one of the most widely preferred methods for rigid registration of 3-D surfaces. However, iterative approaches like ICP are highly dependent on the initial conditions such as distance of a person from the camera, resolution of camera and an intensity of light on camera**.** In most of the current 3-D face recognition systems, the surface initialization is handled by accurately locating a set of facial landmark points. ICP algorithm requires matching criteria in order to find correspondences between the points of the surfaces to be registered. In our work, we have used a projective matcher. Based on the assumption that the rough registration computes a good registration (i.e. with a low error) between the mean face and the candidate face surface, the projective matcher tries to find correspondences using orthographic projections of each vertex. For each point located at coordinate (i, j) in the data image space, the corresponding point is searched in the model image space in locations $(i \pm r, j \pm r)$; where $r \geq 1$ is an integer which defines a square region around the current location. The correspondence criterion is the point at minimum Euclidean distance.

C. Occlusion Detection

After the facial surfaces have been registered, it is important to locate facial areas occluded by exterior objects. The most straightforward approach for occlusion detection is to analyze the difference of the input image from a mean face. If an exterior object coveres a part of the facial surface, the difference for this specific area will be more evident. This ensures the detection of occluded areas by thresholding the difference map obtained by computing the absolute difference between the average face and the input face. Prior to occlusion detection, the facial surfaces are resampled from a regular grid to construct the depth images. Regular resampling enables only the coordinates namely the depth values to be considered for a sufficient comparison. If the depth images for the input face and the average face model are denoted by x and **xavg** respectively, the occlusion mask is obtained by thresholding the absolute difference:

$$m(j) = \begin{cases} 1 & \text{if } |x(j) - x_{avg}(j)| > t \\ 0 & \text{otherwise} \end{cases}$$

Here t denotes the pre defined threshold value.

D. Face Recognition

Once the face is detected then it is very important to recognize valid authenticated face from a large dataset. For this we are using Principal Component Analysis. It is the fundamental technique for image reconstruction. Image reconstruction using PCA computes the principal component scores from a part of the input image and reconstructs the whole input image according to the principal component scores. The main idea is to decorrelate data in order to highlight differences and similarities by finding the principal directions (i.e. the eigenvectors) of the covariance matrix of a multidimensional data. The reconstruction accuracy depends on the detection accuracy of occluded regions, since it is necessary to accurately detect occluded regions and compute principal component scores from the pixels which are having high resolution (effective pixels).

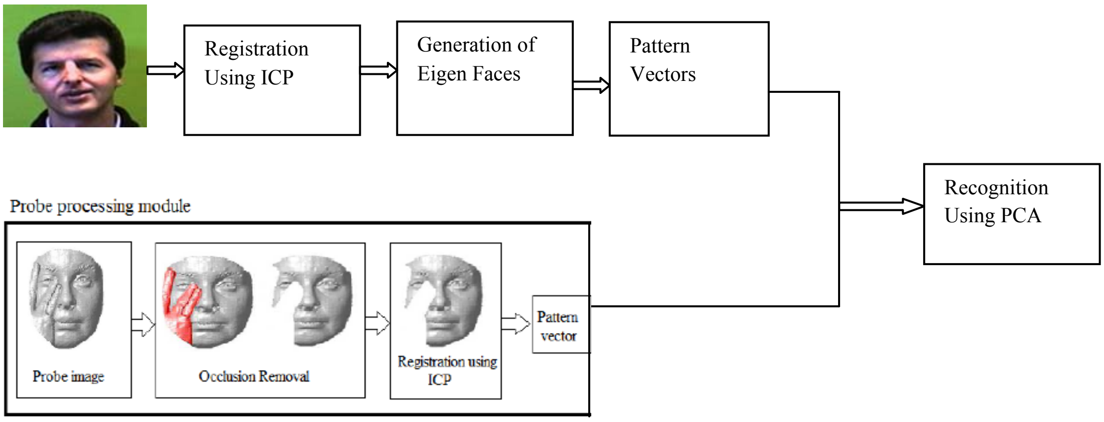


Fig.3: Proposed method for Face detection and Recognition

Face registration using PCA can be done with the following steps.

Input data = $x_1, x_2, \ldots, x_M$ are $N \times 1$ vectors.

Step1: $\bar{x} = \frac{1}{M}\sum_{i=1}^{M} x_i$

Step2 : subtract the mean : $\{\Phi_i\}_{(N\times 1)} = \{x_i - \bar{x}\}_{(N\times 1)}$

Step3 : form matrix $A = [\Phi_1 \quad \Phi_2 \quad .. \quad \Phi_M]_{(N\times M)}$,

find the covariance matrix

$$\{C\}_{(N\times N)} = \frac{1}{M}\sum_{j=1}^{M}\Phi_j\Phi_j^T = \left\{\frac{1}{M}A_{(N\times M)}A^T{}_{(M\times N)}\right\}_{(N\times N)}$$

Step4 : find eigen values of C : $\lambda_1 > \lambda_2 > .. > \lambda_N$

Step5 : find eigen vectors of C : $u_1, u_2, \ldots, u_N$

Step6 : Find eigen vectors u_i of $\{AA^T\}_{(N_{total}\times N_{total})}$,

($e.g.size(A)$ is $N_{total} \times M = 10304 \times 300$)

$AA^T u_i = \lambda_i u_i$

$C = \frac{1}{M}AA^T$ = is too large to be calculated in limited time,

Size of $C = N_{total} \times N_{total} = 10304 \times 10304$ if $Nc = 92, Nr = 112$

Step6.1: find eigen of A^TA (size MxM)

(instead of eigen of $C = AA^T$(size N2xN2))

e.g. $M = 300$ training images, then A^TA (size 300x300)

Step 6.2: Find v_i the eigen vectors of A^TA.

$u_i = eigen\_values\_of\,(AA^T)_{(N_{total}\times N_{total}=10304\times 10304)}$, and

$v_i = eigen\_values\_of\,(A^TA)_{(M\times M=300\times 300)}$

relation of u_i and v_i

$(AA^T)u_i = \lambda_i u_i - - - - - (i)$

$(A^TA)v_i = \beta_i v_i - - - - - - (ii)$

from (ii) : β_i is an eigen value (scalar) of A^TA

multiply each size of (ii) by A

$\Rightarrow A(A^TA)v_i = A\beta_i v_i = \beta_i A v_i$, since β_i is a scalar

$(AA^T)Av_i = \beta_i(Av_i) - - - - (iii)$

Compare (iii) with (i)

$u_i = Av_i$ and $\lambda_i = \beta_i$

So, AA^T and AA^T have the same eigenvalue

and eigen vectors are related : $u_i = Av_i$

Step6.3 :

Find the best M = 300 eigen vectors $u_{i=1,2..300}$

and M = 300 eigen values $\beta_{i=1,2,..M}$ of $(A^TA)_{(M\times M=300\times 300)}$

The first M eigen values λ_i of (AA^T) and eigen values β_i

of (A^TA) are the same

$\beta_{i=1,2,..M} = \lambda_{i=1,2,..M}$

Also

$u_i = Av_i$

normalize u_i, so $\|u_i\| = 1$

Step7 : Only the K(e.g = 5) biggest Eigen vectors (eigen avlues) are useful in most cases

PCA describes the variation in a set of multivariate data in tems of a set of uncorrelated variables. PCA is the simplest of the true Eigenvector -based multivariate analysis. The working step of PCA is given in Fig 4. It removes the correlation among the different input dimensions and significantly reduces the data dimensions.

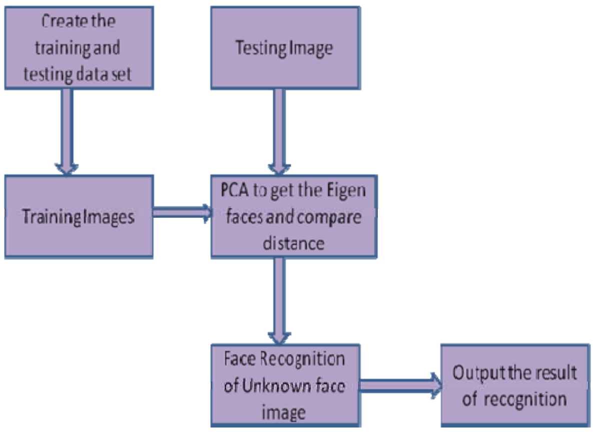
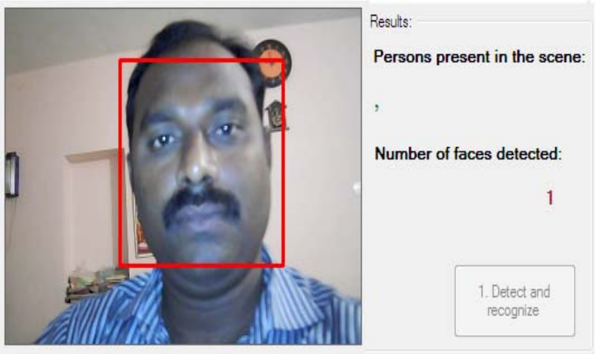


Fig4: Working of PCA algorithm

IV. EXPERIMENTAL RESULT

We are providing video as an input to our system in the real time. Fig.5 is the snapshot of the given video at a particular time instant t1 and t2 respectively. We can also notice that the detected face in the video has been marked by red square box. Hence result shows that face from the input video is detected and number of face detected is also mentioned. But these faces are not registered till now hence detected face is not matching with data base.

Detection of Face at time t1



Detection of Face at time t2

Fig.5. Detection of Face at given instant of time

Figures 6 and.7 shows detection and recognition of face by matching the captured face with database. It shows name of the detected person and number of face detected.

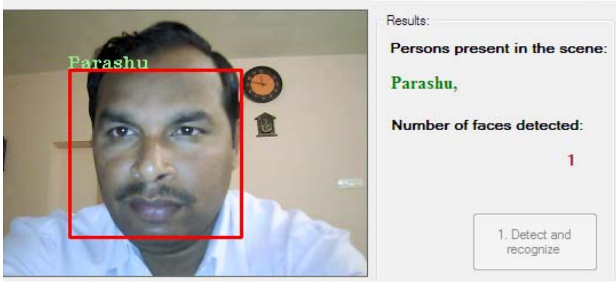


Fig 6: Face Detection and Recognition

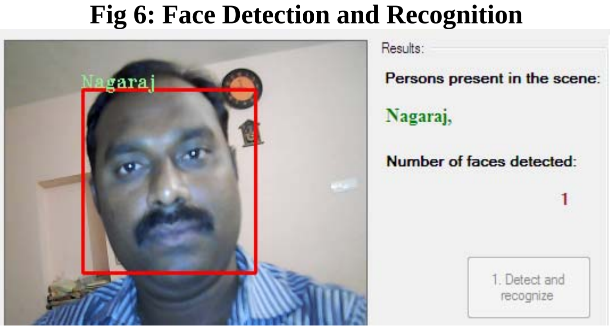


Fig 7: Face Detection and Recognition

In the next stage, we can notice that recognition of face of a person is successful even when some parts of the face are occluded or covered by exterior object. Fig.8 shows recognition of person when mouth and nose area are occlude by hand and Fig.9 shows the recognition of person correctly when part of the face is occlude by hand.

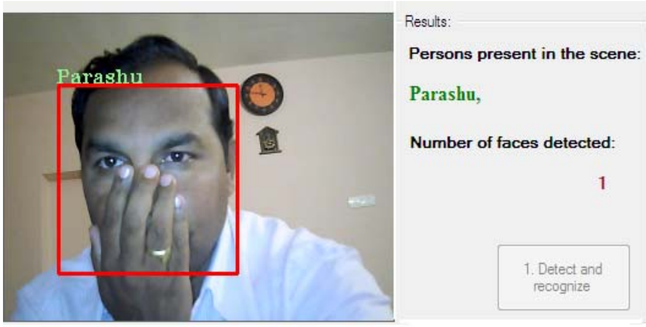


Fig.8. Detection and Recognition of occlude face

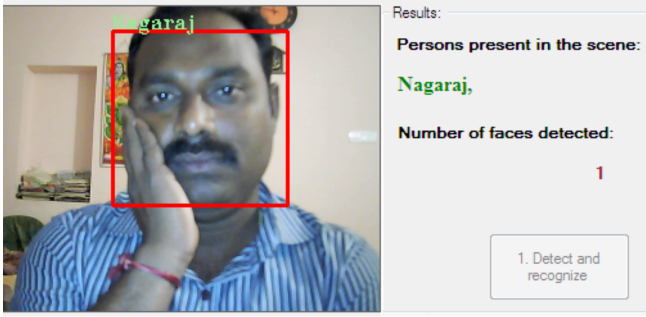


Fig.9. Detection and Recognition of occlude face

The proposed system is able to detect and recognize multiple occluded faces at given instance of time. The Fig10 shows the recognition of multiple occlude faces.

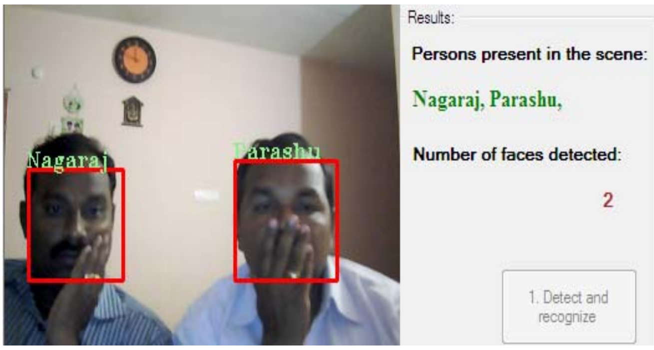


Fig.10 Multi faces Recognition under occlusion

V. CONCLUSION

The proposed system has been found to perform well under substantial occlusions, expressions and small pose variations. Following the occlusion detection stage, the facial parts are detected and recognized. Experimental results demonstrate that the proposed algorithm reliably recognizes partially occluded faces with higher recognition rate than the existing methods. The result obtained confirms the high security in biometric authentication system using face as a case study.

REFRENCES

[1] A. F. Abate, M. Nappi, D. Riccio, and G. Sabatino, "2D and 3D facerecognition: A survey," *Pattern Recognit. Lett.*, vol. 28, no. 14, pp.1885–1906, 2007.

[2] A. F. Abate, S. Ricciardi, and G. Sabatino, "3D face recognition in aambient intelligence environment scenario," in *Face Recognition*, K.Delac and M. Grgic, Eds. Vienna, Austria: I-Tech, 2007.

[3] N. Alyuz, B. Gokberk, and L. Akarun, "A 3D face recognition systemfor expression and occlusion invariance," in *Proc. Int. Conf. Biometrics:Theory, Applications and Systems (BTAS)*, 2008, pp. 1–7.

[4] N. Alyuz, B. Gokberk, and L. Akarun, "Regional registration for expressionresistant 3-D face recognition," *IEEE Trans. Inf. ForensicsSecurity*, vol. 5, no. 3, pp. 425–440, Sep. 2010.

[5] N. Alyuz, B. Gokberk, and L. Akarun, "Adaptive model based 3D faceregistration for occlusion invariance," in *Proc. Eur. Conf. ComputerVision—Workshops—Benchmarking Facial Image Analysis Technologies(BeFIT)*, Florence, Italy, 2012.

[6] A. Colombo, C. Cusano, and R. Schettini, "Recognizing faces in 3Dimages even in presence of occlusions," in *Proc. Int. Conf. Biometrics:Theory, Applications and Systems (BTAS)*, 2008, pp. 1–6.

[7] A. Colombo, C. Cusano, and R. Schettini, "Gappy PCA classificationfor occlusion tolerant 3D face detection," *J. Math. Imag. Vis.*, vol. 35,no. 3, pp. 193–207, 2009.

[8] A. Colombo, C. Cusano, and R. Schettini,"3D occlusiondetection and restoration of partially occluded faces," *J. MathImag. Vis.*, vol. 40, no. 1, pp. 105–119, 2011.

[9] A. Colombo, C. Cusano, and R. Schettini, "UMB-DB: A databaseof partially occluded 3D faces," in *Proc. Int. Conf. Computer Vision(ICCV)—Workshops*, 2011, pp. 2113–2119.