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3D Face Recognition As A Biometrics and Its Diverse Applications

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Abstract— Biometrics defines quantifiable characteristics of measuring features of biological organism. 3D Face recognition is a promising trend in Computer Vision and Image Processing research. Face is considered as one of the most attractive biometrics due to its uniqueness. All the anatomical information from the face can be retrieved without physical intervention. In this paper a comparative analysis of region based approach in 3D Face recognition with its diverse applications in security and autism prediction is highlighted. Experiments are done on Bosphorus dataset and a third party dataset, reports a verification rate of 95.3% at 0.1% false acceptance rate. In Identification scenario the Rank one recognition rate is 99.3%. Running time of Modified Face Recognition Algorithm (MFRA) is determined and analyzed.

Keywords- Biometrics, 3D Face Recognition, MFRA, Verification Rate, False Acceptance Rate, Rank One Recognition ,ASD.

I. INTRODUCTION

Face recognition attained a lot of relevance in identification scenario due to a number of advantages. It is one of the most unintrusive biometric techniques available now a day and is considered as one of the most attractive biometrics. Face is the most widely used identifier or tokens for representing people. We can see the face images in almost all the personal documents; from this itself we can understand the relevance of face as an important biometrics for personal identification. We can obtain lot of information like age, gender, emotions, expressions etc from a human face. Face can be considered as a wide channel that contains information about us.

In biometrics context recognition refers to the capability to perform verification and identification. Government, personal and commercial applications are using biometrics for security purposes. 3D face recognition is getting more attention now a day in machine learning scenario. Due to multiple application in different realms of life, the possibilities of this area is increasing and lots of companies and centres are working on it.

Recognition scenario with face biometrics is broadly classified into 2D face recognition and 3D face recognition. Image capture conditions play a vital role in 2D face recognition where as geometrical depth information is highlighted in 3D. Advanced technologies in data capturing and increased computational power create new directions in 3D face recognition research and its applications

The paper is organized as follows, Section I contains the introduction of Face recognition, Section II contain the related work, and Section III highlights the two Face Recognition system approaches developed by us with essential steps and figures. Section IV focus on the results and its analysis, Section V contain the diverse applications of the developed face recognition system and Section VI concludes the comparative study with future directions.

II. RELATED WORK

Faltemier et al. [1] proposed a region based approach by extracting 28 sub regions from frontal face. They report a rank one recognition of 97.2% and a Verification rate of 93.2% at false acceptance rate (FAR) of 0.1%. Experiments are all done on FRGC v2 dataset. They extend their work by increasing the number of sub regions to 38.

Mian et al. [2] automatically segmented the face into sub regions. A spherical representation of the face, SIFT transformation and a modified Iterative closest point algorithm is used for recognition.

Chang et al. [3] make use of regions from the frontal face for 3D face recognition. The regions are extracted from the nose area.

Zhong et al. [5] divides the frontal face into two portions, the lower and upper face region. The upper face region is region without the mouth. K-means clustering and nearest neighbour classifier is used for obtaining results.

Lie et al. [7] presents a 3D face recognition approach based on low level geometric features. These features are extracted from nose, fore head and eyes region.

Reji et al. [8] worked on altered finger prints and analyzed the relevance of using multi biometrics in security applications.
W.AbdAlmageed et al. [9] investigates about the use of deep learning models in multi pose face recognition. Experiments are done to analyze the results of landmark detection.
Ding et al. [10] worked on a face identification frame work that is based on full range of pose variation. A patch based face representation scheme was introduced.
Klontz et al. [11] motivates to study the need for community driven open source software in biometrics applications.
Akarun et al. [12] focus on 3d face recognition and its applications
Silberberg et al. [14] study on the prevalence of neuro-developmental disorder among children aged 2 to 9 years in the different regions in India.
Vezzetti et al. [15] focused on 3D human face descriptions; land marks measures and geometrical features.
Gupta et al. [16] highlights on the assumption that different facial expressions can be considered as isometric deformation of facial surfaces.

III. 3D FACE RECOGNITION SYSTEM

This paper focus on a comparative analysis of our two 3D faces recognition system with its diverse application in security and medical domain. Initial work [4] employs a region based approach with the following steps: Image acquisition, Preprocessing, Nose tip detection, Region extraction/alignment to gallery, finally comparison and output. 100mm of frontal face region from a third party dataset was used for this approach. A 3X3 median filter is applied for preprocessing, refer figure 1.After preprocessing nose tip is detected manually. With the detected nose tip as origin, 48 sub regions are extracted from the frontal face. These regions are stored in the gallery (trained database). Test database contain all the images that is to be tested. So the comparison is occurring between the probe and gallery. The MFRA (Modified Face Recognition algorithm) is applied and based on a threshold value the system is generating a match or not. The system reports a verification rate of 93.7 % at FAR 0.1%, see figure2, 5.

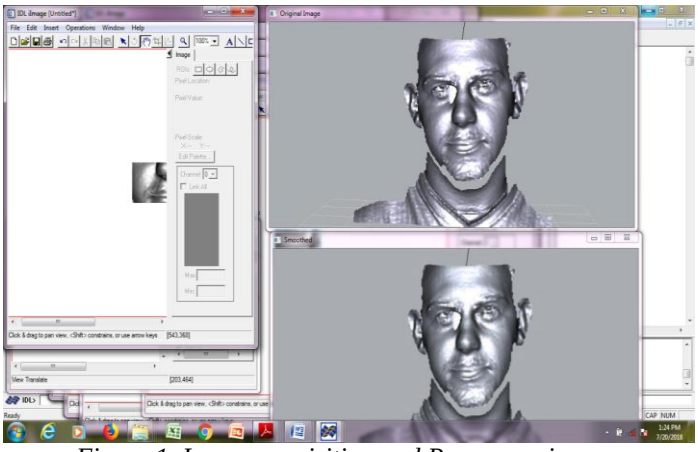

Figure 1. Image acquisition and Preprocessing.

RESULTS FOR REGION=48
% Compiled module: $MAIN$.
MATCHED IMAGE FOR REGION 39: 5
MATCHED IMAGE FOR REGION 40: 5
MATCHED IMAGE FOR REGION 41: 5
MATCHED IMAGE FOR REGION 42: 5
MATCHED IMAGE FOR REGION 43: 5
MATCHED IMAGE FOR REGION 44: 5
MATCHED IMAGE FOR REGION 45: 5
MATCHED IMAGE FOR REGION 46: 5
MATCHED IMAGE FOR REGION 47: 5
MATCHED IMAGE FOR REGION 48: 5
HIGHEST SCORE = 45
VERIFICATION RATE = 93.750000
IMAGE SHOWING HIGHEST SCORE 5
MATCHED IMAGE IS IMAGE NUMBER : 5

Figure 2. Sample Output Console for 48 regions

In our second work Region based 3D face Recognition [6] the system was implemented in two modes of operation with five steps: Pre-processing, Automatic detection of nose tip, Sub region creation/ alignment, MFRA and Contour based image registration. The two modes of operations are the verification mode and confirmation mode. The major limitation of our initial work is the use of third party dataset and manual detection of nose tip. The use of bench marked Bosporus dataset [18] along with a fully automatic nose tip detection algorithm overcome the above limitations and provide good results. For experiments third party dataset is also used which ensures the performance of the algorithm in real world applications.

The benchmarked dataset ensures the performance of our algorithm with the standard algorithms available in this area. Instead of extracting 48 regions, only 15 regions are extracted from the frontal face, see figure 3, 4. The major highlight of this work is the use of a contour based image registration technique in the confirmation mode.

The system reports a verification rate of 95.3% with a false acceptance rate of 0.1%. The Rank one recognition rate is 99.3% in identification scenario, see figure 6.

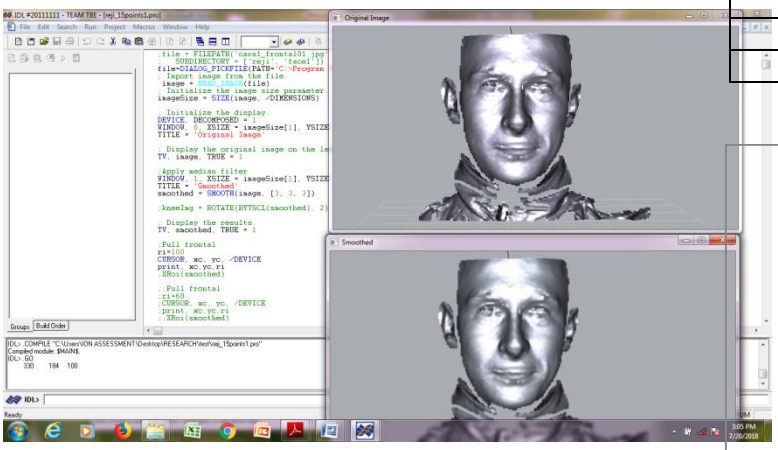

Figure 3. Pre-processing

Figure 4. Sample Regions

IV. RESULTS AND ANALYSIS

Analyzing the above methods and works from the literature it is evident that our region based approach performs well rather than using the full frontal face region. In initial work 48 regions are extracted and are stored in the gallery for probe comparison. But in region based 3d face recognition paper we are considering only 15 regions that contain any one portion of the core identifier such as nose, mouth and eyes. This technique yields comparatively good results.

The running time of the modes get improved and is evident from the table 1, 2. In approach 1 with 48 regions the overall running time of MFRA is 12.72 seconds where as in approach 2 with 15 regions and contour based image registration the overall running time is reduced to 11.6 seconds. While analyzing the running time and verification rate our system is well suited for time critical security applications.

Table 1. Running time of MFRA for 48 regions.

Sl no:	Steps	Time in Seconds
1	Pre-processing	4.59
2	Matching	8.13

Table 2. Running time of MFRA for 15 regions.

Sl no:	Steps	Time in Seconds
1	Pre-processing	4.54
2	Matching	1.94
3	Registration	5.12

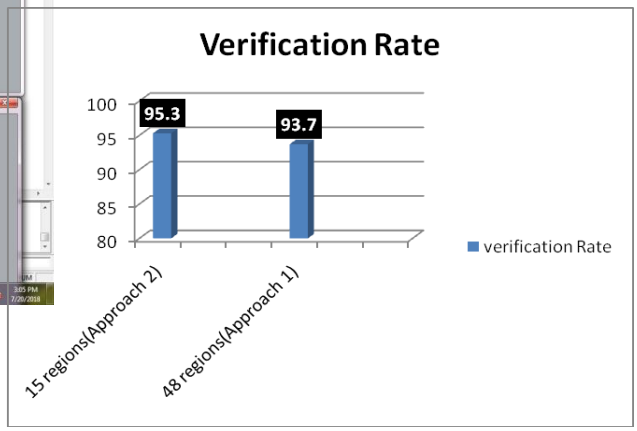

Figure5. Verification Rate.

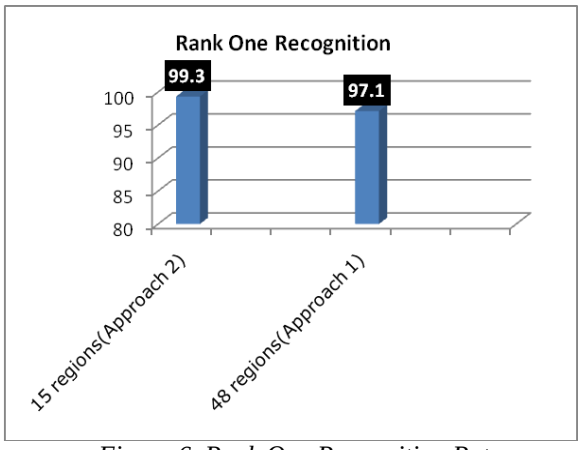

Figure 6. Rank One Recognition Rate.

V. APPLICATIONS

A) SECURITY DOMAIN

Our region based 3D face recognition is having two diverse applications, one in security domain and another in Medical domain. The major application is in security domain. System is tested in distributed parallel processing environment. Implementation diagram [13] of the system is as shown in figure 7.

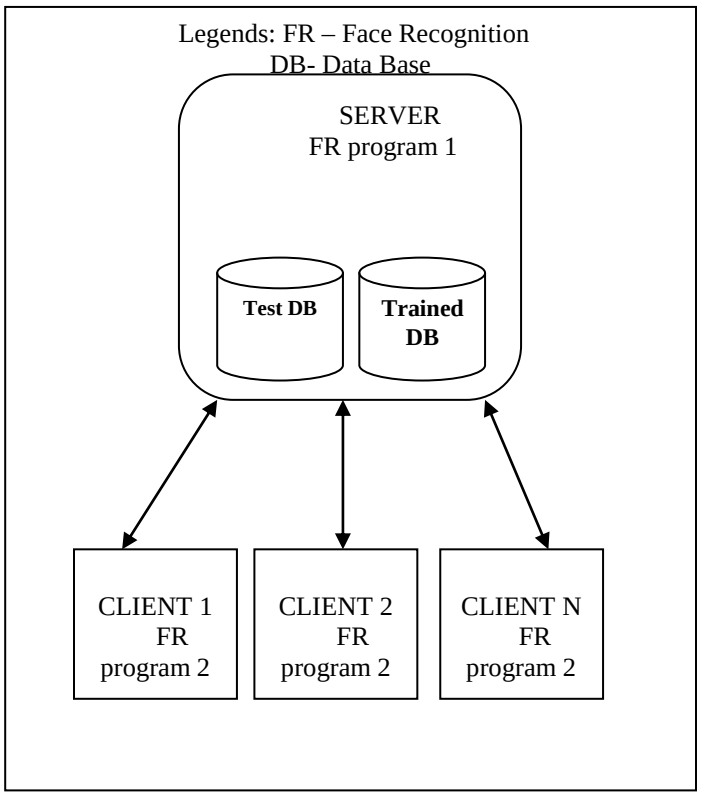

Figure 7. [13] Implementation of FR systems.

The system can be mainly used for criminal identification purpose. As mentioned two modes of operations namely the verification mode and confirmation mode are available. The databases used are trained database, probe database and trained database. The FR system is implemented as two programs one running in the client side and one running on the Server side. Let's elaborate the working of our application in detail. Consider the scenario in which the server is residing on the police head quarters and all the police stations under the head quarters act as the client. Test database is storing the images of criminals. Trained database is the gallery which contains the sub regions of the images that is used for training the database. Probe database is used for temporarily storing the image under question. The trained database and the test database reside on the server. In any police station if a criminal arrived we need to check whether the criminal is a member of the wanted list by acquiring his image and give it to the FR system. It will compare the image with the test database and report match or not. This is the verification mode. In the verification mode the MFRA (Modified Face recognition Algorithm) calculates the similarity measure based on some threshold.

If the similarity score is S and Threshold is T, Then if S >=T only a mach occurs. If the value of S is just below T, Then the confirmation phase come to play and the contour based image registration technique is applied to find a match or not. This system can be implemented in time critical security areas such as airport check points and ATMs etc. The complete implementation of the system with its detailed explanation and running time calculation is available [13].

B) MEDICAL DOMAIN

Another important Application of the proposed 3D face recognition system is in the medical domain. Autism Spectrum Disorder (ASD) is a clinically heterogeneous developmental disorder. It is having a range of symptoms. Early diagnosis and proper intervention is necessary for the effective treatment. We have designed an expert system that will acts as support system for the clinician. Major clinical attribute along with 3D facial features are used as input for the expert system. The system is having two modes of operations, diagnosis mode and grading mode.

The overall system is implemented using a neuro fuzzy approach. In diagnosis mode 100% accuracy and in Grading mode 98.8% accuracy is obtained.

The architecture of the expert system is as shown in the figure 8 [17].

The major highlight of the system is the use of the facial features as input to the expert system, see figure 9 [17].

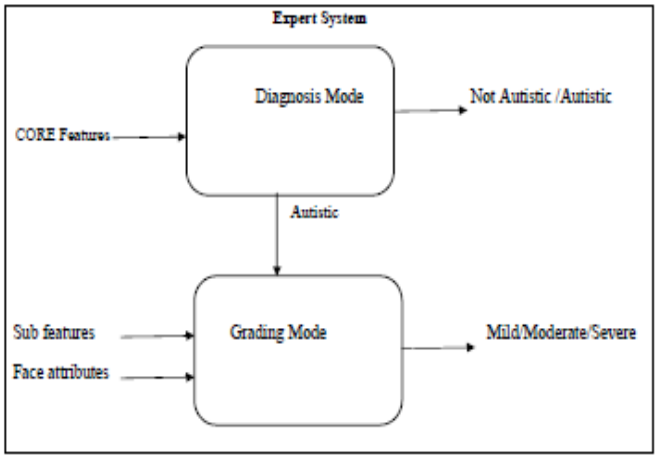

Figure 8. [17] Architecture of Expert System

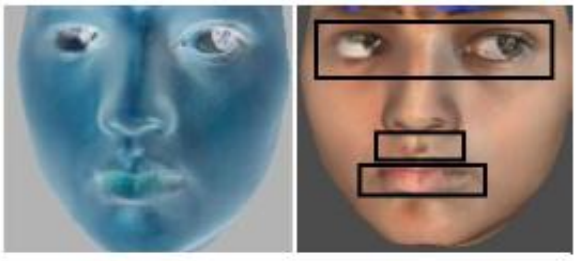

Figure 9. [17] 3D Facial Features.

VI. CONCLUSIONS

We have presented a comparative analysis of the two region based 3D face recognition approaches. In one method 48 sub regions are extracted from frontal face where as in the second method 15 regions are extracted and a contour based image registration is applied. The results and running time of both the approaches are analyzed. The second approach is having more relevance in time critical security applications. One of the key contributions of the work is the use of 3D facial features obtained from the second approach can be used for design of an expert system for autism diagnosis.

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