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Modified Technique of Three Dimensional Face Recognition in the Presences of Facial Expression

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***Abstract*—** Face recognition has acquired abundant attention in market and research communities, but still remained very accosting in real time applications. It is one of the various techniques used for identifying an individual. The major factors affecting the face recognition system are pose, illumination, identity, occlusion and expression. The image variations due to the change in face identity are less than the variations among the images of the same face under different illumination, expression, occlusion and viewing angle. Among the several factors that influence face recognition, illumination and pose are the two major challenges. Next to pose and illumination, the major factors that affect the performance of face recognition are occlusion and expression. So in order to overcome these issues, we proposed an efficient 3d face recognition system based on partial occlusion and expression. The similar blocks in the face image are identified. Then the occlusion can be recovered using the block matching technique. Finally, the face can be recognized by using the PCA. From the implementation result, it is proved that the proposed method recognizes the face images effectively.

***Keywords*—**Facerecognition,OcclusionDetection,Expression,BlockmatchingAlgorithm,PrincipalComponentAnalysis(PCA)

I. INTRODUCTION

Among all the recent biometric techniques, face recognition systems have received the most attention due to the non-intrusion nature of the person involved in recognition. It is more convenient to users when compared to other individual identification methods of biometric features. It involves pattern recognition, image processing, intelligent learning and so on [1]. Face recognition, a kind of biometric identification, researched in several fields such as computer vision, image processing, and pattern recognition is a natural and direct biometric method [2]. Automated methods that use facial features as essential elements of distinction to determine identity are involved in the process of facial recognition. The recognition performance thoroughly degrades with pose and lighting variations [3]. Face recognition involves categorization of extremely confusing multi-dimensional input signals, and matching them with the known „signals" and it is an extremely complicated type of pattern recognition.

Information security, law enforcement and surveillance, smart cards, access controls are some of the areas of applications for face recognition [4], [5], [6].

A face is basically a 3D object amidst random background objects lighted by diverse lighting sources from several directions. Because of this, when a face is projected against a 2D image its appearance varies remarkably [7]. Major changes in 2D appearance are also caused by diverse pose angles. Capability of figuring out identity in spite of such changes in appearance that a face can have in a setting is needed for robust face recognition. At the same time problems like noise, camera distortion or image resolution should not affect the working of the system. The variation caused by factors such as occlusion, illumination, expression, pose, accessories and aging produces a performance drop in all the face recognition algorithms [8].

II. RELATED WORK

Illumination, Occlusion, Expression and pose are the main confronts to face recognition out of the diverse factors that affect 3d face recognition. In that, occlusion and expression variation considerably reduces the performance of recognition. So to tackle this problem, the face with different occlusions and expression is recognized under by our proposed system. Few expressions based and occluded face recognition approaches have been proposed earlier.

De Marsico et al. [9] proposed face recognition for occlusions and expression variations. It is based on the concept of partitioned iterated function systems (PIFS) which compute a map of self-similarities within the whole input face image and search for the relation among small square regions. Algorithms of this kind suffer from local distortions such as occlusions. To overcome this, information extracted by PIFS is made local by working independently on each face component like eyes, nose, and mouth. Distortions are further reduced by means of an ad hoc distance measure.

Tarrés et al [10] have presented a face recognition method that could be able to manage with partial occlusion or variations in face expression. Their method solves the face recognition problem from a near holistic perspective. The concept behind this approach was to eliminate the few features that cause reduction in recognition accuracy under variations in occlusion or expression.

Aleix M. MartõÂnez [11] has described a probabilistic approach that was able to compensate for imprecisely localized, partially occluded, and expression-variant faces even at one single training sample per class was available to the system. To determine the occlusion problem, each face was divided into k local regions which are analysed in isolation. In contrast with other approaches where a simple voting space is used, they presented a probabilistic method that analyses how good a local match was.

Kepenekci et al [12] have proposed an approach to feature based frontal face recognition using Gabor wavelets. The features were automatically extracted using the local characteristics of each individual face in order to decrease the effect of occluded features. There were no training as in neural network approaches, thus single frontal face for each individual was enough as reference.

Dahua Lin and Xiaoou Tang [13] have proposed a method to detect and recover the occluded facial region automatically. It frees the user from marking the occlusion area by incorporating an automatic occlusion detector, that learns a face quality model as a criterion to guide the whole procedure and it couples the detection and occlusion stages to achieve accurate occlusion detection and high quality recovery simultaneously.

Kazuhiro Hotta [14] has presented the use of Support Vector Machine (SVM) with local Gaussian summation kernel for robust face recognition under partial occlusion. Because conventional methods apply one kernel to global features and global features were influenced easily by noise or occlusion, the conventional methods are not robust to occlusion. The recognition method based on local features, was robust to occlusion because partial occlusion affects only specific local features. In order to utilize their property of local features in SVM, local kernels were applied to local features. The effectiveness and robustness of their method are shown by comparison with global kernel based SVM.

Hyun Jun Oh et al. [15] have proposed a novel occlusion invariant face recognition algorithm based on Selective Local Nonnegative Matrix Factorization (S-LNMF) technique. The algorithm was composed of two phases; the occlusion detection phase and the selective LNMF-based recognition phase. They used local approach to effectively detect partial occlusion in the input face image.

As a result of systematic literature review, numbers of open chances have been discussed. But identification of more specific parameters and area to be worked requires even more mysterious critical analysis which has been listed as gaps found during the survey. In accordance with scope and significance discussed in the earlier chapter, the actual and specific problems have been stated in this section. This tends to be the base of this dissertation work. Following problems have been identified:

- There are two limitations in Two Dimensional Face Recognition are namely Translation and Rotation because of this 3D Face Recognition is required.
- LDA is unable to provide accurate results in terms of Features classification that's why k-NN is required.

III. Methodology

This paper presents a Riemannian framework for 3D facial shape analysis. This framework is based on elastically matching and comparing radial curves emanating from the tip of the nose and it handles several of the problems described above. The main contributions of this paper are as follows:

- It extracts, analyses, and compares the shapes of radial curves of facial surfaces.
- It develops an elastic shape analysis of 3D faces by extending the elastic shape analysis of curves to 3D facial surfaces.
- To handle occlusions, it introduces an occlusion detection and removal step that is based on recursive-ICP.
- To handle the missing data, it introduces a restoration step that uses statistical estimation on shape manifolds of curves. Specifically, it uses PCA on tangent spaces of the shape manifold to model the normal curves and uses that model to complete the partially observed curves.
-

A. Radial,Elastic Curves:Motivation

An important contribution of this paper is its novel use of radial facial curves studied using elastic shape analysis.
The changes in facial expressions affect different regions of a facial surface differently. For example, during a smile, the top half of the face is relatively unchanged while the lip area changes a lot, and when a person is surprised the effect is often the opposite. If chosen appropriately, curves have the potential to capture regional shapes and that is why their role

becomes important. The locality of shapes represented by facial curves is an important reason for their selection.
The past usage of the level curves (of the surface distance function) has the limitation that each curve goes through different facial regions and that makes it difficult to isolate local variability. The previous work on shape analysis of facial curves for 3D face recognition was mostly based on level curves [17], [18].

B. Motivation for Elasticity

Consider the two parameterized curves shown in Fig. 1; call them β1 and β2. Our task is to automatically match points on these radial curves associated with two different facial expressions. The expression on the left has the mouth open, whereas the expression on the right has the mouth closed. To compare their shapes, we need to register points across those curves.

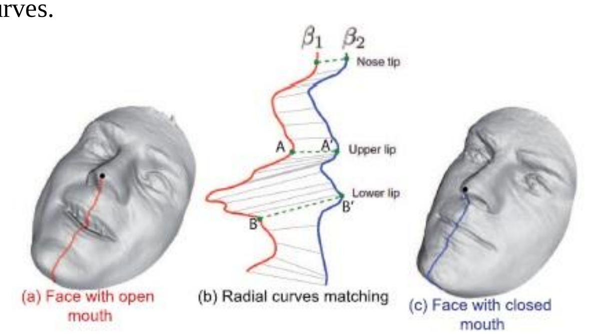

Fig.1. an example of matching radial curves extracted from two faces belonging to the same person: a curve with an open mouth (on the left) and a curve with a closed mouth (on the right). One needs a combination of stretching and shrinking to match similar points (upper lips, lower lips, etc.).

One would like the correspondence to be such that geometric features match across the curves as well as possible. In other words, the lips should match the lips and the chin should match the chin. The points A and B on β_1 will not match the points A' and B' on β_2 as they are not placed at the same distances along the curves. For curves, the problem of optimal registration is actually the same as that of optimal re-parameterization. This means that we need to find a re-parameterization function γ(t) such that the point $\beta_1(t)$ is registered with the point $\beta_2(\gamma(t))$, for all t.

As described in [16], this registration is accomplished by solving an optimizing problem using the dynamic programming algorithm, but with an objective function that is developed from a Riemannian metric. The chosen metric, termed an elastic metric, has a special property that the same re-parameterization of two curves does not change the distance between them. This in turn enables us to fix the parameterization of one curve arbitrarily and to optimize over the parameterization of the other. This optimization leads to a proper distance (geodesic distance) and an optimal deformation (geodesic) between the shapes of curves. In other words, it results in their elastic comparisons.

C. Proposed Algorithm

Input: Facial surface s_1 and s_2.
Output: The distance d_s.
for i←1to2do
for α←0to2∏do
Extract the curve β_α^i;
if quality (β_α^1) =1 and quality (β_α^2) =1 then
Compute the optimal rotational and re-parameterization alignment O_α^* and γ_α^*.
set $q_\alpha^{2*}(t) = \sqrt{\dot{\gamma}_\alpha^*(t)} O_\alpha^* q_\alpha^2(\gamma_\alpha^*(t)))$
compute
$d_s([q^1{}_\alpha],[q^2{}_\alpha]) = \cos^{-1}(<q^1{}_\alpha, q^2{}_\alpha>)$
end
end
compute $d_s = 1/n \ \Sigma_{\alpha \varepsilon A} \ d_s(q^1{}_\alpha, \ q^{2*}{}_\alpha)$, Where n is the number of valid pairs of curves.
end.

D. 3D Face Recognition on The Bosphorus Dataset: Recognition Under External Occlusion

In this section, we will use components I (occlusion detection and removal) and II (missing data restoration) in the algorithm. The first problem we encounter in externally occluded faces is the detection of the external object parts. We accomplish this by comparing the given scan with a template scan, where a template scan is developed using an average of training scans that are complete, frontal, and have neutral expressions. The basic matching procedure between a template and a given scan is recursive ICP, which is implemented as follows:
In each iteration, we match the current face scan with the template using ICP and remove those points on the scan that are more than a certain threshold away from the corresponding points on the template. This threshold has been determined using experimentation and is fixed for all faces. In each iteration, additional points that are considered extraneous are incrementally removed and the alignment (with the template) based on the remaining points is further refined.

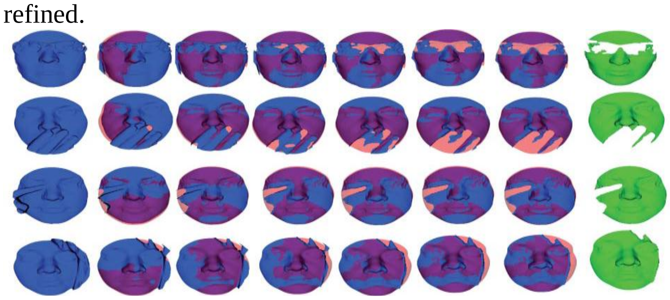

Fig.2. Gradual removal of occluding parts in a face scans using recursive-ICP.

Fig. 2 shows an example of this implementation. From left to right, each face shows an increasing alignment of the test face with the template, with the aligned parts shown in magenta, and also an increasing set of points labelled as extraneous, drawn in pink. The final result, the original scan minus the extraneous parts, is shown in green at the end.

In the case of faces with external occlusion, we first restore them and then apply the recognition procedure. That is, we detect and remove the occluded part and recover the missing part, resulting in a full face that can be compared with a gallery face using the metric d_S. The recovery is performed using the tangent PCA analysis and Gaussian models. To evaluate our approach, we perform this automatic procedure on the Bosphorus database. The Bosphorus database is suitable for this evaluation as it contains scans of 60 men and 45 women, 105 subjects in total, in various poses, expressions, and in the presence of external occlusions (eyeglasses, hand, and hair). For each subject there are four scans with occluded parts. These occlusions refer to-
1. Mouth occlusion by hand,
2. Eyeglasses,
3. Occlusion of the face with hair, and
4. Occlusion of the left eye and forehead regions by hands.

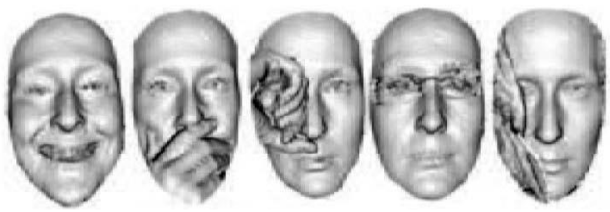

Fig.3. Examples of faces from the Bosphorus database. The un-occluded face on the left and the different types of occlusions are illustrated.

IV. Results and Discussion

In the following section, a comparative performance analysis of proposed method with other state-of-the-art solutions has been provided using the Bosphorus dataset.

A. Data Preprocessing

Since the raw data contains a number of imperfections, such as holes, spikes, and includes some undesired parts, such as clothes, neck, ears, and hair, the data pre-processing step is very important and nontrivial. As illustrated in Fig. 5, this step includes the following items:

- The hole-filling filter identifies and fills holes in input meshes. The holes are created either because of the absorption of the laser in dark areas, such as eyebrows and must matches, or self-occlusion or open mouths. They are identified in the input mesh by locating boundary edges, linking them together into loops, and then triangulating the resulting loops.
- A cropping filter cuts and returns part of the mesh inside a Euclidean sphere of radius 75 mm cantered at the nose tip to discard as much hair as possible.

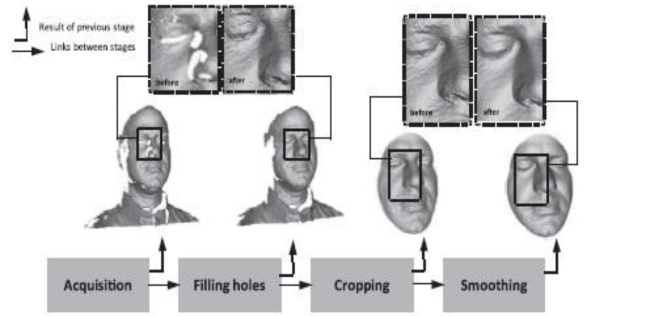

Fig.4. the different steps of preprocessing: acquisition, filling holes, cropping, and smoothing.

- A smoothing filter reduces high-frequency components (spikes) in the mesh, improves the shapes of cells, and evenly distributes the vertices on a facial mesh.

The proposed novel face recognition approach is implemented in NetBeans and face recognition was performed using the set of Bosphorus Database, Yale Database and JAFFE database under various expression and occlusion conditions. The results show that proposed approach has an encouraging performance.

B. Databases

- The Japanese Female Facial Expression (JAFFE) Database

  The database contains 213 images of 7 facial expressions posed by 10 Japanese female models. Each image has been rated on 6 emotion adjectives by 60 Japanese subjects [18].

  Interpret the findings in view of the results obtained in this and in past studies on this topic. State the conclusions in a few sentences at the end of the paper. However, valid colored photographs can also be published.

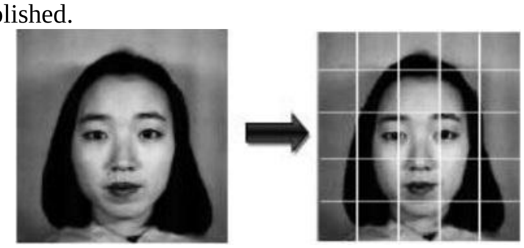

Fig.5. Block division process in JAFFE Database images

- Yale Database

  The database contains 165 GIF images of 15 subjects. There are 11 images per subject, one for each of the following facial expressions or configurations: centre-light, w/glasses, happy, left-light, w/no glasses, normal, right-light, sad, sleepy, surprised, and wink [18].

Fig.6. Block division process in Yale Database images

In our proposed method, we used Bosphorus databases which contain the 3face images with various pose, illumination, occlusion and expression.

V. Conclusion and Future Scope

In this paper a framework for a statistical shape analysis of facial surfaces have been presented. We have also presented results on 3D face recognition designed to handle variations of facial expression, pose variations, and occlusions between gallery and probe scans. This method has several properties that make it appropriate for 3D face recognition in non-cooperative scenarios. First, to handle pose variation and missing data, we have proposed a local representation by using a curve representation of a 3D face and a quality filter for selecting curves. Second, to handle variations in facial expressions, we have proposed an elastic shape analysis of 3D faces.

Finally, in the presence of occlusion, it is proposed to remove the occluded parts, then to recover only the missing data on the 3D scan using statistical shape models. That is, we have constructed a low dimensional shape subspace for each element of the indexed collection of curves, and then represent a curve (with missing data) as a linear combination of its basis elements. The testing of proposed approach was carried out in a simulated environment using NetBeans environment. NetBeans provides an interactive environment with hundreds of reliable and accurate built-in mathematical functions. Recognition results demonstrate that it effectively minimize FAR and FRR. Finally Elastic Distance Computation algorithm improves the accuracy of the face recognition system. The research proposals made out of this paper have opened several challenging research directions, which can be further investigated. The recognition rate using the proposed Elastic Distance Computation algorithm approach applies to future work. Also in the future it can be combined with other methods and thus even improve the robustness and accuracy. Next, we need to improve the performance of classifier and the face potential area selection method. Future works can also include experiment this method on other 3D face databases.

VI. COMPARATIVE ANALYSIS

The recognition accuracy of the proposed approach is compared with some existing approaches. Computing the false acceptance rate (FAR) and false rejection rate (FRR) is the common way to measure the biometric recognition accuracy. FAR is the percentage of incorrect acceptances i.e., percentage of distance measures of different people's images that fall below the threshold. FRR is the percentage of incorrect rejections - i.e., percentage of distance measures of same people's images that exceed the threshold. The following equation is used to calculate the accuracy measurement of the overall approach,

$$Accuracy = 100 - [\frac{FAR - FRR}{2}]$$

Genuine acceptance rate (GAR) is an overall accuracy measurement of the approach. The following table gives the percentage of the recognition rates and the accuracy rates.

Table 1 comparisons results of proposed hybridized technique with other existing methods

Methods	Databases								
	Yale Database			Jaffe Database			Bosphorus Database		
	FRR (%)	FAR (%)	Accuracy (%)	FRR (%)	FAR (%)	Accuracy (%)	FRR (%)	FAR (%)	Accuracy (%)
Face recognition based on Occlusion	4.18	5.48	96.3	4.75	5.92	95.8	1.08	1.14	99.47
Face recognition based on Expression	5.37	6.72	95.4	6.02	7.1	94.3	1.00	1.17	99.41
Proposed Technique	3.64	4.84	98.4	4.32	5.12	97.7	1.05	1.32	99.99

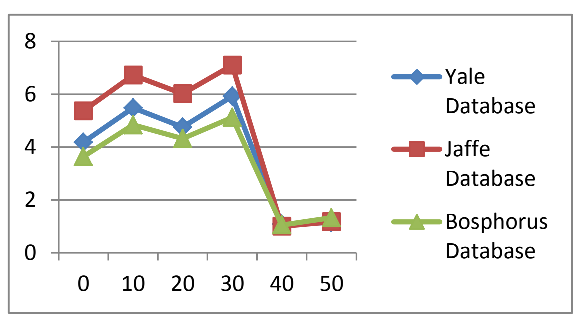

Fig.7. Comparison results of proposed hybridized technique with other existing methods

A. False Acceptance Rate, False Rejection Rate

In this table, we calculate the measures for Bosphorus Database, Jaffe and Yale database. The result shows that our proposed method has a lower value of FAR and FRR error rate in both the databases. Moreover, the proposed system has a higher accuracy compared to the other two methods. Bosphorus Database gives the better result when compared with the Jaffe database and Yale database because it is a standard database when compared to the Jaffe database and also the Bosphorus database contains more expression images than Jaffe database and Yale. Normally expression image is more difficult to recognize than occluded image. So Bosphorus database gives better accuracy in face recognition system. It is evident that the proposed face recognition system efficiently recognizes the face under various expression and occlusion.

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