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Study of 3D face recognition using Fourier Descriptors

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***Abstract*—In this paper a Fourier Descriptor based face recognition system is proposed, which uses Fourier descriptors of Features for identification of faces. The Fourier descriptor is used to describe the boundary of a shape in 2 dimensional space using the Fourier .The advantage of using the Fourier descriptor is reduces a 2-D into a 1-D problem. Fourier descriptor of a input image is matched with Fourier descriptor of registered image using simple matching algorithms. The proposed system of face recognition may be applied in identification systems.**

***Keywords*— Face Recognition, Contour Tracing, Fourier Descriptor, Biometrics, Image Processing.**

I. INTRODUCTION

There is an increasing demand for security in commercial and law enforcement applications. Many recent events, such as terrorist attacks, exposed serious weakness in most sophisticated security systems. Various government agencies are now more motivated to improve security data systems based on body or behavioural characteristics, often called biometrics [1]. A biometrics is "Automated methods of recognizing an individual based on their unique physical or behavioral characteristics."

In general, biometric systems process the raw data in order to extract a template which is easier to process and store, but carries most of the information needed. It is a very attractive technology, because it can be integrated into any application requiring security or access control, effectively eliminating risks associated with less advanced technologies that are based on what a person have or know rather than whom a person really is.

Face recognition technologies have made great progress for the past few decades. Although they played an important role in many applications such as identification, crowd surveillance and access control under the controlled inner and outer environments there are still many unsolved problems in varying environments such as pose, illumination and expression.[1]

Face recognition systems fall into two categories: verification and identification. Face verification is a 1:1 match that compares a face image against a template face images, whose identity is being claimed. On the contrary, face identification is a 1:N problem that compares a query face image against all image templates in a face database to determine the identity of the query face. At last a third scenario, the watch list, has been proposed in Face Recognition Vendor Test .The test individual may or may not be in the system database. The query face image is compared against all the face images in the database, computing a score for each one.

The rest of paper is organized as follows. In the following section we will introduce the database which we are using and briefly review methodology used in a face recognition system. The next section will discuss our image processing technique and our work on allocating certain facial features such as the nose, eyes, lips and the outline of a face. In addition we will discuss the brief information related to the terminology used by us

II. ABOUT DATABASE

The database used for experiment is the subset of the FEI face database composed of only frontal face images. The FEI face database is a Brazilian face database that contains a set of face images taken between June 2005 and March 2006 at the Artificial Intelligence Laboratory of FEI in São Bernardo do Campo, São Paulo, Brazil. There are 14 images for each of 200 individuals, a total of 2800 images. All images are colourful and taken against a white homogenous background in an upright frontal position with profile rotation of up to about 180 degrees. Scale might vary about 10% and the original size of each image is 640x480 pixels. All faces are mainly represented by students and staff at FEI, between 19 and 40 years old with distinct appearance, hairstyle, and adorns. The numbers of male and female subjects are exactly the same and equal to 100. Figure 1 shows some examples of image variations from the FEI face database.

In addition, database provide a subset of the FEI face database composed of only frontal face images previously aligned to a common template so that the pixel-wise features extracted from the images correspond roughly to the same location across all subjects. . All these frontal images were then cropped to the size of 360x260 pixels. Since the number of subjects is equal to 200 and each subject has two frontal images (one with a neutral or non-smiling expression and the other with a smiling facial expression), there are 400 full frontal face images manually registered to evaluate experiments on a controlled environment.

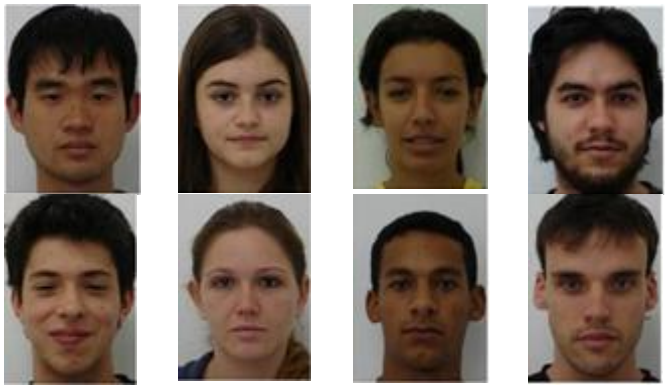

Fig 1 : Sample Images from FEI face Database

III. PREVIOUS WORK

Several approaches are used in the literature for 3D Face Recognition. Some of these are based on the segmentation of the face into meaningful points, lines and regions. Others are considered as model based approaches using information about texture, edges, and colours.[2]

Among the existing approaches for addressing 3D face recognition systems is Profile-based approach was used by Zhang et. al. They first identify the symmetry plane of facial data. Then symmetry profile is computed, and then using mean curvature plot of the facial surface, and mean curvature plot of the symmetry profile three feature points are recognized. The feature points on the nose define the Face Intrinsic Coordinate System FICS; all faces are aligned according to their FICS. For detection purposes the symmetry profile with another two transverse profiles provide a compact representation of the face called SFC face representations. For comparisons purposes SFC representations of faces are compared. 382 different scans database was used. EER for face authentication with variant facial expression reported was 10.8%. For scans with normal expressions .8% EER was reported. The symmetry profiles of two models to be compared are fist registered by mean of ICP algorithm. Then translation is done to make the cheek, forehead, and symmetry profiles coincide in the two models. The comparison is done by a set of sampling points on the corresponding profiles. Semiautomatic pre-processing procedure is used to trim of the non facial regions in the raw mesh. 166 individuals were used of which 32 individuals have multiple scans, and others have one scan.

Gokberk et al. compare five approaches to 3D face recognition. They compare methods based on EGI, ICP matching, Range Profile, PCA, and Linear Discriminate Analysis LDA. The database they used was of 571 images from 160 people. They found out that ICP and LDA approaches offer the best performance, although performance is relatively similar among all approaches but PCA. Gordon segmented the face based on curvature description, and then he extracted a set of features that describes both the curvature and metric size properties of the face. Thus each face becomes a point in the feature space, and the matching algorithm is done by nearest neighbouring algorithm.

Nagamine extracted five feature points and used it to standardize face pose, and then matching various curves or profiles though the face data. According to this experiment the best recognition rates were achieved using vertical profiles that pass through the central region of the face.

Achermann approached 3D face recognition based

on an extension of Hausdorff distance matching. 240 images were used, and 100% recognition rate was reported.

PCA were applied by to address the problem of recognizing people based on 3D images. 37 different individual with 6 images individual were used. Each image per subject has different facial expression.

the 3D face data to an eigenform that is invariant to the type of shape deformation. The assumption is that the change of the geodesic distance due to facial expression is insignificant. Experiments are done using a database of 220 images of 30 persons and 100% recognition rate was reported. A total of 65 enrolment images were used for the 30 subject. ”the use of more than one enrolment image per person will generally increase recognition rates, most unusual aspect of work is the claim that it can distinguish between twins identical)”. Lee et all. Approached the problem based on the curvature values at eight feature points on the face. Using support vector machine for classification they report a rankone recognition rate 96% for a data set representing 100 persons. The feature points were manually allocated. Profile-based approach was used by Zhang et. al. They first identify the symmetry plane of facial data. Then symmetry profile is computed, and then using mean curvature plot of the facial surface, and mean curvature plot of the symmetry profile three feature points are recognized.

The feature points on the nose define the Face Intrinsic Coordinate System FICS, all faces are aligned according to their FICS. For detection purposes the symmetry profile with another two transverse profiles provide a compact representation of the face called SFC face representations. For comparisons purposes SFC representations of faces are compared. 382 different scans database was used. EER for face authentication with variant facial expression reported was 10.8%. For scans with normal expressions .8% EER was reported. The symmetry profiles of two models to be compared are fist registered by mean of ICP algorithm. Then translation is done to make the cheek, forehead, and symmetry Profiles coincide in the two models. The comparison is done by a set of sampling points on the corresponding profiles. Semiautomatic pre-processing procedure is used to trim of the non facial regions in the raw mesh. 166 individuals were used

of which 32 individuals have multiple scans, and others have one scan.

IV. Features Extraction

This section briefly explains our approach for processing images, localization the feature of the image, which will used for recognition purposes.

In our approach, our first goal is to automatically determine the shape information of feature from face image. This is undertaken by means of extracting edge of feature like nose, eyes, leaps that accurately represents the features. In order to find the boundary of feature first couture of that face image gets extracted. In this, the whole face is treated as a contour map, with the areas of constant gray level brightness (i.e. the plains) enclosed by the contour lines. Thus contour lines for a given face can be generated.

The contour of a given image is as shown in Figure 2B

Fig 2-A: input Face Image

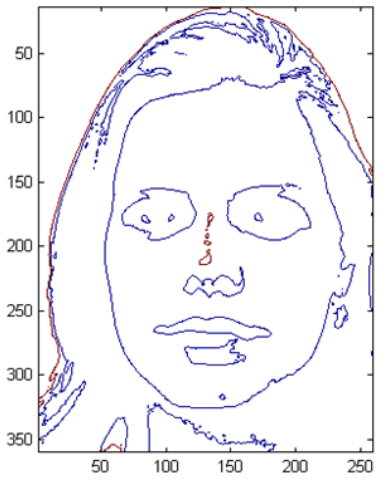

Fig 2-B Contour of a input image

Contour tracing is a technique that is applied to digital images in order to extract their boundary [7]. Contours are represented by vectors; once the Contour extraction is successfully determined we can perform computation of invariant Fourier Descriptors of that contour. Appropriate pre-processing steps make Fourier Descriptors invariant to common transformations, translation, changes in scale and rotation. This Fourier Descriptor values are used for recognition purpose.

We first extract an experimental region which contains the eyes, the nose, the mouth and boundary of the face image in the form of contour. Contour of a face image is represented as a complex vector as follows

$$\tilde{U} = \begin{pmatrix} x_0 + iy_0 \\ x_1 + iy_1 \\ \cdot \\ \cdot \\ x_N + iy_N \end{pmatrix} \quad (1)$$

Here, $\tilde{U}$ complete set of coordinates describing the boundary of various features. Applying Fourier Transform for computing the Fourier coefficients of shape information extracted form face image[5] The discrete Fourier Transform of $\tilde{U}_k$ gives

$$\tilde{F}_\mu = FFT\left[\tilde{U}\right] = \sum_{K=0}^{N-1} \tilde{U}_k \, exp\left(\frac{2\pi i}{N} k\mu\right) \quad (2)$$

The complex coefficients $\tilde{F}_\mu$ called as Fourier descriptors of the boundary.

So for our recognition matching algorithm, we use the Fourier descriptors of boundary information of various features like Eyes, nose, lips (Figure 2B) and boundary of face. The cheeks profile is simply the profile that have contour of a face image. In order to minimize the input data, we compute the Fourier coefficients of the designated profiles and store it in a database, other than storing the actual points of the profile. Thus, having a database of images representing different individuals where each person is represented by profiles stored by means of their Fourier's.

Matching faces against each other is carried out by profile-by-profile comparisons.

V. .Conclusions

In this paper we introduced a technique for processing 3D images of human faces and extract certain features to be used for recognition purposes. In addition, we have demonstrated that utilizing Fourier Descriptors of a human face is very useful in terms of improving recognition rates and minimizing the search space. For the further work we will implement our proposed recognition model on whole database and find out the recognition rate.

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