3D Face Recognition on GAVAB Dataset

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Abstract

This paper describes an Efficient 3D face recognition system. The challenges in 2D face recognition technology has been solved using 3D face recognition approach. The exploration of new face recognition technology that is 3D Face Recognition is widely used for security at many places like airport, organizations etc. The uncontrolled conditions of real-world biometric applications pose a great challenge to any face recognition approach. Such pose variations can cause extensive occlusions, resulting in missing data. so that, in this paper, we present 3D face recognition system to solve those problems. dimensionality of face image is reduced by the Principal component analysis (PCA) and the recognition is done by the Euclidean distance algorithm. System used GAVAB 3D database and calculated some performance metrics like Performance ratio and Execution time.

1. Introduction

Biometrics has been used substantially in personal security and access control applications. Fingerprint, face, iris and voice are commonly used biometric traits. Among these traits, face provides a more direct, friendly and convenient identification method. Face recognition is more acceptable to users compared to other individual biometric traits.

There is two ways we can recognize the face 2D Face recognition and 3D Face recognition. Comparison between 2D and 3D Face recognition [1] given below:

- In 2D based approach, facial features recognized based on measurements such as distance between the eyes, width of the nose, and length of jaw while in 3D based approach, it used the contours of the nose, chin, eye sockets etc. to recognize the facial features.
- In 2D based, face orientation accommodated up to around 15 to 20 degrees while in 3D based, face orientation up to 90 degrees can be accommodated.
- In 2D based, face need to be reasonably well illuminated otherwise Poor lighting can significantly impact performance but in 3D, Range camera with infrared light can be used in low light condition as well.
- Web camera or digital camera used in 2D Face recognition while Stereoscopic or range camera used in 3D Face recognition.

There are two major challenges faced during the testing, those are illumination problem and pose variation problem [2]. Both these problems are serious and cause the degradation of the existing system.

1.1. Illumination Problem

Illumination problem occur when same image appear differently due to illumination condition. If the illumination is larger than the difference between the individuals then the system will not be able to recognize the input image. Lighting variability include not only intensity, but also direction and number of light sources. like same person with the same facial expression and seen from the same view point, can appear dramatically different when light sources illuminate the face from different direction.

1.2. Pose Problem

Recognize the face image of different poses that is pose problem. If rotation (in tilt or yow) induced vary large changes in face appearance and recognition rate fall drastically when one tries to match images from two different poses of same subject using any well known recognition technique.

The motivation to use 3D face technology was to overcome the disadvantages of 2D face recognition systems that arise especially from significant pose, expression and illumination differences.

Rest of the paper is organized as follow Section 1 represents the introduction of the 3D face recognition. Section 2 describes the related work done on 3D face recognition. The system's description and algorithm is explained in section 3. Database related information is presented in Section 4 and We have given details of VRML (Virtual Reality Modeling

Language) in Section 5. finally, simulation and result of the system has been discussed in the Section 6 and Observation and conclusion are describe in last Section.

2. Literature Survey

Many Surveys has been published about the 3D Face Recognition, they are given as below.

Ajmal Mian et.al.,[3] describe fully automatic 3D face recognition algorithm is presented. Several concept are introduced to make the recognition robust to pose correction and efficient. it include 1) Automatic 3D face detection by detecting the nose; 2) Automatic pose correction and normalization of the 3D face as well as its corresponding 2D face using the Hotelling Transform.

Hassen Drira et.al.,[4] explore the use of shapes of elastic radial curves to model 3D facial deformations, caused by changes in facial expressions. they also introduce a quality control module which allows their approach to be robust to pose variation and missing data. Comparative evaluation using a common experimental setup on GAVAB[10] dataset.

Georgios Passalis et.al.,[5] present a novel 3D face recognition method is proposed that uses facial symmetry to handle pose variations. It employs an automatic landmark detector that estimates pose and detects occluded areas for each facial scan. Subsequently, an Annotated Face Model is registered and fitted to the scan. During fitting, facial symmetry is used to overcome the challenges of missing data. The result is a pose invariant geometry image. Unlike existing methods that require frontal scans, the proposed method performs comparisons among interpose scans using a wavelet-based biometric signature. The average rank-one recognition rate of the proposed method in these was 83.7 %.

Utsav Prabhu et.al.,[6] propose a new method for real-world unconstrained pose-invariant face recognition. they first construct a 3D model for each subject in their database using only a single 2D image by applying the 3D Generic Elastic Model (3D GEM) approach. These 3D models comprise an intermediate gallery database from which novel 2D pose views are synthesized for matching. Before matching, an initial estimate of the pose of the test query is obtained using a linear regression approach based on automatic facial landmark annotation.

Preeti.B.Sharma et.al.,[2] analyzed the various algorithm of 3D face recognition through which they conclude that 3D face recognition solves the challenges which were found in the result of 2D face recognition mainly the illumination and pose problem through the analysys.

Dr. Alaa Hamdy et.al.,[7] represent face recognition system that overcomes the problem of changes in facial expressions in three-dimensional (3D) range images. The depth map of 3D facial image is first threshold to discard the back ground information. Then, the detected face shape is normalized to standard size 100x100 pixels and nose point is selected to be the image centre. Image depth values are scaled between 0 and 255 and nose tip has the highest value 255 for translation and scaling invariant identification. The (2D) principle component analysis is applied to the resultant range data for feature extraction. The system performance is tested against the GAVAB database.

3. 3D Face Recognition System

This paper describes an efficient 3D face recognition system, in that Feature extraction is done by Principal component analysis (PCA) after pre-processing stage and euclidean distance algorithm is used for recognition. System consist of four major steps and its block diagram is shown in fig. 3.1.

(i) Pre-processing
(ii) Feature Extraction
(iii) Matching and decision.

3.1. Pre-processing

In preprocessing stage, it resize the face and removes noise using median filter to smooth them as well as unnecessary details.

3.2. Feature extraction

Principal Component Analysis (PCA) [8] is applied on training data sets of each pose. Dimensionality reduction using PCA is achieved by selecting only a few basis vectors among the set of basis vectors depending on their significance. Significance is decided on the basis of eigen vectors preserving the most of energy, which is interpreted from their corresponding eigen values. Total energy is the sum of eigen values of all the eigen vectors and preserved energy is the sum of eigen values of only the chosen eigen vectors. Once the significant eigen vectors are selected, the images are projected into the reduced vector space, that is, the vector space formed only by the selected significant eigen vectors. This projection coefficients form the feature vector and the reduced vector space forms the feature space. A feature vector is either a column vector or row vector consisting of either the actual image pixel values or values obtained after applying a feature extraction techniques. The algorithm for PCA[9] is as follows.

Let the training set of images be $[\Gamma_1, \Gamma_2 \ldots \Gamma_M]$.

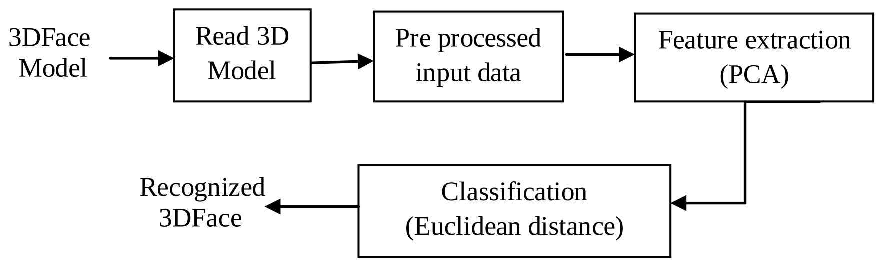

Fig. 3.1. 3D Face Recognition System diagram

The average face of the set is defined by,

$$\Psi = \frac{1}{M}\sum_{n=1}^{M} T_n \qquad (1)$$

Each face differs from the average by vector,

$$\varphi_i = \Gamma_i - \Psi \qquad (2)$$

The co- variance matrix is formed by,

$$C = \frac{1}{M}\sum_{n=1}^{M} \varphi_n . \varphi_n^T = A.A^T \qquad (3)$$

Where the matrix $A = [\varphi_1, \varphi_2 ... \varphi_M]$

This set of large vectors is then subject to principal component analysis, which seeks a set of M

Ortho normal vectors $u_1 .... u_M$.

To obtain a weight vector Ω of contributions of individual eigen-faces to a facial image Γ, the face image is transformed into its eigen-face components projected onto the face space by a simple operation

$$\omega_K = u_K^T(\Gamma - \Psi) \qquad (4)$$

For k=1,.., M', where M' ≤ M is the number of eigen-faces used for the recognition. The weights form vector Ω = $[\omega_1, \omega_2 \ldots \omega_M]$ that describes the contribution of each Eigen-face in representing the face image Γ, treating the eigen-faces as a basis set for face images. The simplest method for determining which face provides the best description of an unknown input facial image is to find the image k that minimizes the Euclidean distance ε_K.

$$\varepsilon_K = \| (\Omega - \Omega k) \|2 \qquad (5)$$

3.3. Feature Matching

Euclidean distance method is applied on the feature vector of a 3D. This feature vector is matched with the feature vector of subjects which is stored in the database. A distance based classifier has been proposed for matching because for most of the practical applications, database generally contains only one image for a single person/class. Hence existing techniques using classifier based on discriminant analysis or support vectors may perform well [8]. Best results are found using for distance based classifiers such as euclidean distance.

Euclidean distance between two vectors gives the matching score as:

$$Match\ Score = \sum_{i=1}^{n} (i^{th}\ element\ of\ probe\ vector - element\ of\ gallary\ vetor)^2$$

lesser match score means that two vectors are closer in the Euclidean space and vice versa. If the match score is less than a threshold value, the two vectors are said to be matched or belonging to the same class/person.

4. 3D Dataset

3D means three-dimensional, i.e. something that has width, height and depth (length). Our physical environment is three-dimensional and we move around in 3D every day. Humans are able to perceive the spatial relationship between objects just by looking at them because we have 3D perception, also known as depth perception. As we look around, the retina in each eye forms a two-dimensional image of our surroundings and our brain processes these two images into a 3D visual experience.

3D graphics defines 3D space with a system of three axes,

- X, which is represents to width,
- Y, which is represents to height and
- Z, which is represents to depth.

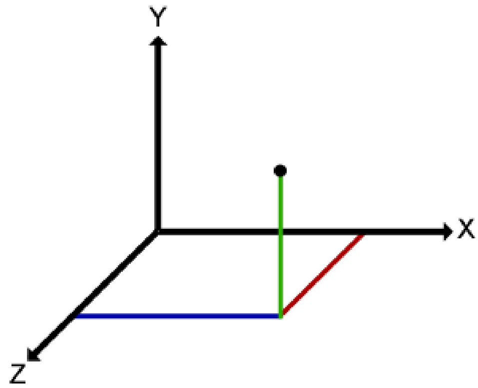

Fig. 4.1. XYZ Axes

Assuming a center point, (through which the X, Y and Z axes all pass), the description of objects in 3D space can be expressed as coordinates representing absolute locations in a 3-dimensional coordinate system, relative to the center point. Each axis has a positive and a negative direction, extending from the center point of the scene. By default, the positive Y axis points up, the positive X axis points right and the positive Z axis points toward the user. Objects within a scene (and the scene itself) may be rotated, causing the orientation of their axes to change accordingly. Once an object's location has been determined, relative to the absolute center, it can then be oriented in one or more of three ways:

- Yaw, rotation about the Y axis (Fig. 4.2),
- Pitch, rotation about the X axis (Fig. 4.3) and
- Roll, rotation about the Z axis (Fig. 4.4)

The three axes (X,Y and Z) and the three rotations (yaw, pitch and roll), together, are referred to as the six degrees of freedom. The location and orientation of objects in 3D space are determined by these six pieces of information.

There are some 3D databases available on which the operations are being performed for 3D face recognition like 3D_RMA database, 3D face database of York University, CASIA-3D FaceV1 and GavabDB[10] 3D dataset which are orientated to different experimentation purposes: automatic face recognition, facial expression analysis, pose estimation, face segmentation from a background plenty of objects, etc. GavabDB is the standard dataset and its freely available, due to this reason for simulation purpose, i have used GavabDB in face recognition experiments which need from 3D face images.

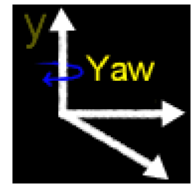

Fig. 4.2 Yaw, Y Rotation

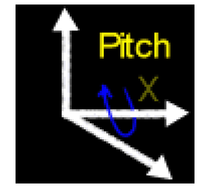

Fig. 4.3 Pitch, X Rotation

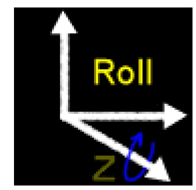

Fig. 4.4 Roll, Z Rotation

GavabDB database contains 3D face images consisting in facial surfaces that represent the faces by three dimensional meshes. As a new feature, this database offers three views per individual in which there are facial expressions (two of them very pronounced). it also includes many variations with respect to the pose of each individual.

GavabDB contains 549 three-dimensional facial surface images corresponding to 61 individuals (45 male and 16 female), and there are 9 different images per each person. The whole set of individuals are Caucasian and most of them are aged between 18 to 40 years. There are systematic variations over the pose and facial expression of each person. in particular, 2 frontal and 4 rotated images without any facial expressions, and 3 frontal images in which the subject presents different and accentuated facial expressions.

5. Virtual Reality Modelling Language

V-Realm Builder is a powerful three dimensional authoring package for the creation of 3D objects and "worlds" to be viewed with V-Realm Browser or any other VRML 2.0 compliant browser. To view a VRML file, you need a VRML viewer or browser, which can be a plug-in for a Web browser like Contact , Cortona3D, Cosmo Player, GLView, 3D Object Viewer, FirstSpace, WorldView but among them Cortona3D is a fast and highly interactive 3D viewer. Sample images are taken from the 3D face GAVAB dataset and displayed using Cortona3D Viewer as well as same image is read using Virtual Reality Modeling Language in Matlab tool (see in fig. 5.1,fig.5.2).

Fig. 5.1. Images display in Cortona3D Viewer

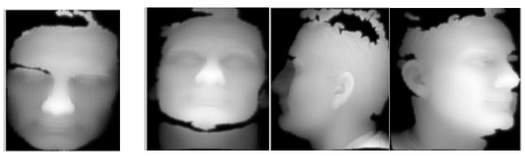

Fig. 5.2. Read VRML images in Matlab tool

6. Simulation and Results

In preprocessing stage, it resize the face and removes noise using median filter then feature extraction is done by the Principal component analysis (PCA) and at the last Euclidian distance is used for classification. We have used GAVAB 3D dataset for testing purpose and measures parameter like recognition rate (RR). We have used training images from one to five per subject and testing images is two for all train cases. 18 subject is used for simulation so total we have tested 90 3D images and result is shown in Table 6.1.

Table 6.1 3D face recognition using GAVAB dataset

Training Images/ Person	**Total Train Images/ Person**	**Testing Images/ Person**	**Total Test Images/ Person**	**RR (%)**
1	18	2	36	27 %
2	36	2	36	47 %
3	54	2	36	50 %
4	7	2	36	50 %
5	90	2	36	75 %

7. Conclusion

Through this analysis we can say that it make use of principal components analysis to generate the feature vector of 3D face from the given face image . The proposed system is tested on GAVAB database. It has been observed that the system performs better recognition rate when we increase the no of training images and further improvement we can get after correcting pose into frontal face.

8. References

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