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A Review Paper on 2D to 3D Face Recognition Technology

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Abstract:
As one of the most successful application of image analysis and understanding A Face recognition has recently gained significant attention. Basically there are two main reasons for such a trend (a) the first is wide range of commercial & law enforcement applications (b) the availability of feasible technologies. Among the diverse contents of multimedia face objects are preferably more important. For ex: a security system that is able to automatically track human objects and report their ID's. However the 2D images of 3D face can dramatically change due to lighting and viewing variation. Face recognition in uncontrolled environment is hindered by variation in illumination, pose, expression & occlusion of faces. Many practical face recognition systems are affected by these variations. One way to increase the robustness to illumination, pose expression and occlusions is to use 3D facial images. In this paper we will be able to understand how we are developing from 2D to 3D face recognition technology with a complete overview of face recognition technology.

Keywords: Face recognition, 2D images, 3D images.

1. Introduction:

Face is the natural assertion of identity. Face is the most widely accepted biometric modality however face recognition presents a challenging problem in the field of image analysis and computer analysis. Face recognition id biometric system used to identify or verify a person from digital image. Face recognition system should be able to automatically detect a facer in an image. This involves extraction, recognition, transformation and poses variation which is a difficult task. Passwords or PIN's are difficult to remember and can be stolen or guessed, cards tokens or keys can be misplaced forgotten or duplicated. Magnetic cards can be corrupted and unclear. However in individual biological traits cannot be misplaced forgotten, stolen or forged.

Face recognition falls into two categories **Verification and Identification**. Face Verification is 1:1 match that matches a face against the template face image whose identity is to be claimed. Face Identification is 1:N match that compares a query face database to determine the identity of query face .

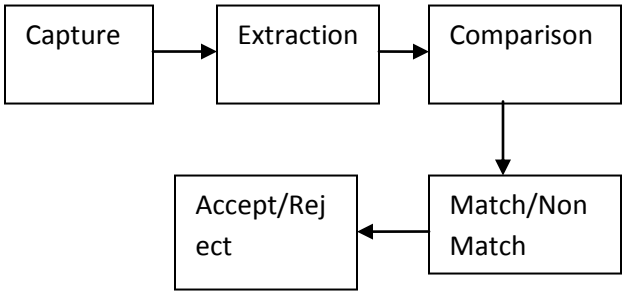

Figure 1

The general block diagram of Face recognition system is shown above. All identification and authentication technologies operate using these four steps:

1. Capture: A physical or behavioral sample is captured by system during enrollment and also in identification or verification process.
2. Extraction: Unique data is extracted from sample and template is created.
3. Comparison: The template created is the compared with a new sample.
4. Match/Non-Match: The system decides if features extracted from new sample are a match or non-match.

2. Face Recognition Methods

In beginning Face Recognition was treated as 2D pattern recognition. The diustance between important points where used to recognize known faces example: measuring

the distance between the eyes or other important points or measuring different angles of facial comparison, the following methods are used for face recognition:

- Holistic Matching Method
- Feature based Matching
- Hybrid Method

Holistic Matching method: In this method the complete face region is taken into account as input data into face catching system. One of the best example of holistic method are Eigen faces, principal component analysis(PCA), linear discriminant analysis(LDA), independent component analysis(IDA) etc.

Feature based method: in this method local feature such as eyes, nose & mouth are first of all extracted and their location and local statistics are fed into structural classifier. Big challenge is face restoration. Feature based method distinguishes between three different extraction methods

- Generic methods based on edges, lines & curves.
- Feature template based method.
- Structural matching methods that take into consideration geometrical constraints on the features.

Hybrid Method: It uses a combination of both Holistic and Feature based method. Generally 3D images are used in this method.

3. 2D Face Recognition

The 2D image data is typically treated as having pose variation only around z axis, the optical axis. The PCA system uses a two landmark points (eye location) for geometric normalization to correct for rotation, scale and position of face for 2D match. However the face is a 3D object and if 3D data is acquired there is the opportunity to correct for pose variation around the x, y and z axis. A transformation matrix is first computed based on angle difference in X & Y between manually selected landmark points i.e. two eye tips and center of lower chin & predefined reference points of standard face pose and location. Pose variation around Z axis is corrected by measuring the angle difference between the line across the two eye point & horizontal line. At the end of pose normalization the nose tip of every subject is transformed to same point in 3D relative to sensor.

4. 3D Face Recognition

3D Face Recognition is a relatively recent trend that in some sense breaks the long term tradition of mimicking the human visual recognition system. 3D facial geometry represents the internal Recognition anatomical structure of face rather than its external appearance influenced by environment factor. As compared to 2D, 3D facial surface is insensitive to illumination, head pose & cosmetic etc.

3D Face recognition has the potential to achieve better accuracy than its 2D by measuring geometry of rigid features on the face.

The main technological limitation of 3D Face Recognition is acquisition of 3D images which usually requires a range camera.

3D face recognition usually consist of following stages

- Preprocessing of raw facial data
- Registration of faces
- Feature extraction
- Matching.

Before proceeding with these steps a 3D face should be localized in given 3D image. However the currently available 3D face acquisition devices have a very limited sensing range & image usually contains only facial area. With the availability of more advanced 3D sensors that have very large range of view we foresee the develop of highly accurate face detection system that use 3D facial shape data together with 2D texture information. The preprocessing step usually involves simple but critical operation such as surface smoothing, noise removal & hole filling. After obtaining noise free facial regions the most important phases are registration & feature extraction. Since human faces are vital for extracting discriminative features. Face registration usually starts with acceptable initial condition.

5. Databases

FRGC (Face Recognition Grand Challenge): FRGC is the first evaluation campaign that focuses expressly on face 2D face at different

resolution & illumination condition & 3D face alone or in combination with 2D. It contains 5000 images where 3D part is divided into two parts: Development(943 images) & Evaluation set(4007 images). Faces were acquired under controlled illumination conditions using a minolta vivid 900/910 sensor, a structured light sensor with a range resolution of 640/480 & a registered color image.

Bosphorus DB: It is a 2D-3D face database including extreme & realistic expression, pose &occlusion variation that may occur in real life. For 3D model reconstruction a region of interest including the central facial region is manually selected thus the background clutter is removed. The texture images are high resolution (1600*1200) with perfect illumination conditions. It contains a total 3396 facial scans acquired from 81 subjects, 51 men and 30 women. It has two parts**: Bosphorus v.1** contains 34 subjects & each subject has 31 scans, 10 types of expression,13 types of poses, 4 occlusions & 4 neutral/frontal scans . **Bosphorus v.2** contains 47 subjects, each subject having 34 scans for different expression including 6 emotional expressions & 28 facial units, 13 scans for pose variation, 4 occlusions & 1 or 2 neutral/frontal faces.

6. Comparison of 2D and 3D Face Recognition

	2D	**3D**
Defination	The eigen vectors of 2D vector space of possible faces of human beings	a class of methjods that work on a 3D dataset representing both face & head shape as range data or polygonal meshes.
How it works	An initial set of 2D face images were acquired the eigen faces were calculated from training set only M eigen faces corresponding to M largest eigenvalues were retained. These eigen faces spanned the face space which constitutes of training set, each face image then will be represented by M weights extremely compact representation	The device module acquires initial 3D facila data & transfer it to processor. The data processing module reconstructs the 3D surface for further recognition. The matching engine module provides comparison of acquired & previously enrolled biometric templates.
Template Size	Small template size	Compact biometric template extracted
Template description	Face features location, texture or combination. Not a real measurement	Description of face shape in 3D face geometry full features description
FAR	0.001	0.001
Accuracy	Medium fully dependent on image resolution	High not so depending on image resolution
Sensitivity	Sensitive to lightning, pose, makeup or expression	Insensitive to lightning pose upto 45 deg, makeup or expression

7. Applications

There are various application of face recognition technology. The natural use of face recognition technology is replacement of PIN, physical

token or both. Let us consider some few application of face recognition technology

1. Government use:
   a) Law enforcement: minimizing victim trauma by narrowing mugshot searches, verifying identify for court records & comparing school surveillance camera images to know a child molester.
   b) Security: access control, comparing surveillance images to know terrorist.
   c) Immigration: rapid progression through customs.
2. Commercial use:
   a) Day care
   b) Residential security
   c) Voter verification
   d) Banking using ATM
   e) Physical access control of building areas, doors, cars or net access.
3. Access control: In many access control applications such as offices or computer logon the size of group of people that need to be recognized is relatively small. The face pictures are also caught under natural conditions such as frontal faces & indoor illumination. It can achieve high accuracy without much co-operation by users.
4. Security: It is prime concern at Airport both for staff and passengers.
5. Image DB investigation: searching image DB of licensed drivers, benefit recipients, missing children, passport etc.

8. Conclusion

3D face recognition has matured to match the performance of 2D facre recognition. Face is a biometric modality that is widely acceptable for general public & face recognition technology is able to meet the accuracy demands of wide range of application. This paper gives us a complete transition from 2D to 3D Face recognition and also the databases that can be used for the same.