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3d Face Recognition Techniques

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Abstract:

Despite some early work in 3D face recognition in the late 1980s [1] relatively few researchers have focused on this area during the 1990s. By the end of the last decade interest in 3D face recognition was revived and has increased rapidly since then. In the following we will review the current state-of-the-art in 3D face recognition. Face recognition is one of the biometric method, to identification of given face image using main features of the face.

Introduction. Face Recognition is the process to identify the input test face from the stored dataset. Face Recognition Technology (FRT) is used in several disciplines such as image processing, pattern recognition, computer vision etc. in which research is been continuously carried out. In the last five years, a rapid increase for the need to design 3D face recognition algorithms has taken place both in academy and industry. However, it is clearly visible that the 3D face recognition technology is at the beginning steps. In recent years, numerous 3D face recognition techniques have been developed. In some respects, 3D face recognition techniques are advantageous relative to 2D techniques. The use of 3D face models is motivated by a number of factors. Firstly, by relying purely on geometric shape, rather than colour and texture information, we render the system invariant to lighting conditions. Secondly, the ability to rotate a facial structure in 3D space, allowing for compensation of variations in pose, aids those methods requiring alignment prior to recognition. Finally, the additional discriminatory depth information in the facial surface structure, not available from two-dimensional images, provides supplementary cues for recognition. As an example, eye separation can be recovered from both sets of data, but nose depth can only easily be recovered from 3D data. We do recognize however, that two-dimensional colour-texture information provides a rich source of discriminatory information, which is forfeit if 3D data alone is used. Therefore, the focus here is to first determine the ability of 3D data alone to form the basis of a face recognition system, as compared to 2D systems.

An overview of 3D face recognition. Three dimensional face recognition techniques based on the appearance of facial range images are similar to 2D holistic appearance based techniques. The only difference being that they employ range images instead of intensity images. For the most part, they are straight forward extensions of techniques that have been successful with 2D facial images. A number of preprocessing and normalization steps are usually required in these algorithms. Their purpose is to localize and segment the human head; remove spike noise and holes (regions of missing data); align heads to a canonical position; and to generate range images in that position. Three or more points on the face are manually or automatically located to determine the head pose. For most algorithms, the canonical position is the frontal pose with the tip of the nose located at the center of the image. The appearance based methods that have been investigated for 3D face recognition include PCA, LDA, LFA, independent component analysis (ICA), hidden Markov models (HMM), and optimal component analysis (OCA).

1.1 Surface-based approaches. Surface-based approaches use directly the surface geometry that describes the face. These approaches can be classified into those that extract either local and global features of the surface (e.g. curvature), those that are based on profile lines, and those which use distance based metrics between surfaces for 3D face recognition.

1.2 Local methods. One approach for 3D face recognition uses a description of local facial characteristics based on Extended Gaussian Images (EGI) [2]. Alternatively the surface curvature can be used to segment the facial surfaces into features that can be used for matching [3]. Another approach is based on 3D descriptors of the facial surface in terms of their mean and Gaussian curvatures[4] or in terms of distances and the ratios between feature points and the angles between feature points [5]. Another locally-oriented technique is based on using point signatures, an attempt to describe complex free-form surfaces, such as the face. The idea is to form a representation of the neighborhood of a surface point. These point signatures can be used for surface comparisons by matching the signatures of data points of a “sensed” surface to the signatures of data points representing the model’s surface. To improve the robustness towards facial expressions, those parts of the face that deform no rigidly (mouth and chin) can be discarded and only other rigid regions (e.g. forehead, eyes, nose) are used for face recognition. In a similar approach this approach has been extended by fusing extracted 3D shape and 2D texture features Finally, hybrid techniques that use both local and global geometric surface information can be employed. In one such approach local shape information, in the form of Gaussian-Hermite moments, is used to describe an individual face along with a 3D mesh representing the whole facial surface. Both global and local shape information are encoded as a combined vector in a low-dimensional PCA space, and matching is based on minimum distance in that space [6].

1.3 Global methods. Global surface-based methods are methods that use the whole face as the input to a recognition system. One of the earliest systems is based on locating the face’s plane of bilateral symmetry and to use this for aligning faces. The facial profiles along this plane are then extracted and compared. Faces can also be represented based on the analysis of maximum and minimum principal curvatures and their directions. In these approaches the entire face is represented as an EGI. Another approach uses EGIs to summarize the surface normal orientation statistics across the facial surface [7].A different type of approach is based on distance-based techniques for face matching. For example, the Hausdorff distance has been used extensively for measuring the similarity between 3D faces. In addition, several modi- fied versions of the Hausdorff distance metric have been proposed . Several other authors have proposed to perform face alignment using rigid registration algorithms such as iterative closest point algorithm (ICP). After registration the residual distances between faces can be measured and used to define a similarity metric In addition, surface geometry and texture can be used jointly for registration and similarity measurement in the registration process, and measures not only distances between surfaces but also between texture. In this case each point on the facial surface is described by its position and texture. An alternative strategy is to use a fusion approach for shape and texture [8]. In addition to texture, other surface characteristics such as the shape index can be integrated into the similarity measure. An important limitation of these approaches is the assumption that the face does not deform and therefore a rigid registration is sufficient to align faces. This assumption can be relaxed by allowing some non-rigid registration, e.g. using thin-plate splines (TPS). Another common approach is based on the registration and analysis of 3D profiles and contours extracted from the face. The techniques can also be used in combination with textureinformation.

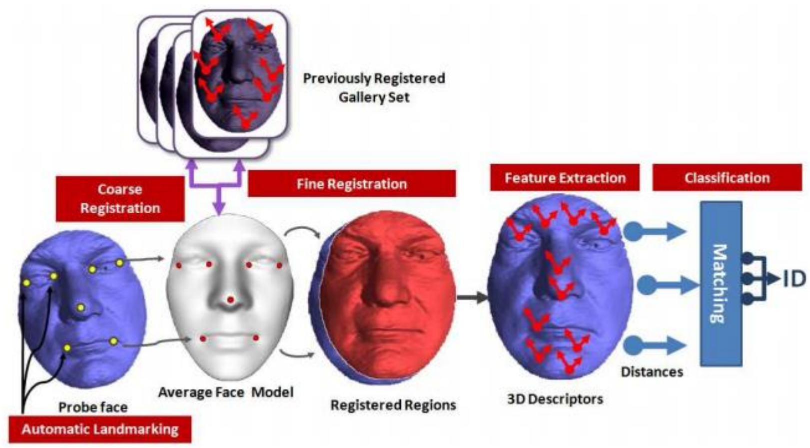

Fig. 1.1 Overall pipeline of a typical 3D face recognition system.

3D Face recognition technology. 3D face recognition system usually consists of the following stages: 1) preprocessing of raw 3D facial data, 2) registration of faces, 3) feature extraction, and 4) matching [9] Figure 1.1 illustrates the main components of a typical 3D face recognition system. Prior to these steps, the 3D face should be localized in a given 3D image. However, currently available 3D face acquisition devices have a very limited sensing range and the acquired image usually contains only the facial area. Under such circumstances, recognition systems do not need face detection modules. With the availability of more advanced 3D sensors that have large range of view, we foresee the development of highly accurate face detection systems that use 3D facial shape data together with the 2D texture information. For instance, 3D face detector that can localize the upper facial part under occlusions is proposed. The preprocessing stage usually involves simple but critical operations such as surface smoothing, noise removal, and hole filling. Depending on the type of the 3D sensor, the acquired facial data may contain significant amount of local surface perturbations and/or spikes. If the sensor relies on reflected light for 3D reconstruction, dark facial regions such as eyebrows and eye pupils do not produce 3D data, whereas specular surfaces scatter the light: As a result, these areas may contain holes. In addition, noise and spike removal algorithms also produce holes. These holes should be filled at the preprocessing phase.

Conclusion. 3D face recognition has matured to match the performance of 2D face recognition. When used together with 2D, it makes face a very strong biometric: Face as a biometric modality is widely acceptable for the general public, and face recognition technology is able to meet the accuracy demands of a wide range of applications. One property of 3D face recognition sets it apart from other biometric modalities: It is inherently a multimodal biometric, comprising texture and shape. Therefore, a lot of research effort has gone into the fusion of 2D and 3D information. There are yet areas to be explored in the interplay of 2D and 3D: How to obtain one from the other; how to match one to the other, how to use one to constrain the other. In the future, with the widespread use of 3D video, the time dimension will open new possibilities for research, and it will be possible to combine 3D face with behavioral biometrics expressed in the time dimension.

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