International Journal of Advanced Computational Engineering and Networking, ISSN: 2320-2106, Volume-2, Issue-2, Feb.-2014

3-D FACES RECOGNITION WITH MISSING PARTS: A REVIEW

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Abstract— This paper presents a survey of face recognition which is a very important task of identifying human faces. Face representations based on 3-D data are expected to be much more complicated to pose changes and illumination variations than 2-D images, thus allowing accurate face recognition also in real-world applications with unconstrained acquisition. FACE recognition using 3-D scans of the face has been recently developed as an alternative or complementary solution to conventional 2-D face recognition approaches working on still images. A possible way to solve locally the problem of missing data in 3-D face acquisition is to detect the absence of regions of the face and use the existing data to reconstruct the missing parts. Traditional 3-D face modelling and recognition methods constrain human faces with either the Lambertian assumption or the same assumption, resulting in suboptimal shape and texture models. This strategy is SIFT-based and performs in a hybrid way that combines local analysis and holistic analysis, associating associating the keypoints between two facial representations of the same subject. Global 3-D face representations for partial face matching have been given in a limited number of works. A canonical representation of the face is that which exploits the isometry invariance of the face surface to manage missing data obtained by randomly removing areas from frontal face scans. 3-D surface approximation which considers spatial variability of specular and use reactions in face modelling and recognition testing. Instead of evolving each test case individually, evolve all the test cases in a test suite at the same time. At the end, the best resulting test suite is minimized. Personalized 3-D face models are estimated from a small number of face images under different lighting conditions with a fixed viewpoint .Both shape and surface reactance properties are calculated locally through minimization of the image differences between the original images and their estimations. Stochastic computational methods and integrability enforcement are employed to handle the nonlinearity and inconsistency issues in the shape and reactance parameter optimization processes to achieve valid results. Recently, pose variations in face recognition captured growing interest from researchers in the fields of computer vision and pattern recognition. An effective strategy to handle pose variations is to use the assistance of 3-D face models, because human heads are nonplanar 3-D objects so that viewpoint changes take place in the 3-D space. Three dimensional model-based face recognition using personalized 3-D models estimated from 2-D images has shown its promise. Such face recognition algorithms perform on a recognition by-synthesis mechanism in the 2-D image spaces or in dimension reduction over shape and surface reactive parameters in the 3-D space. Consequently, the performances of these techniques are greatly dependent on the accuracy of the estimated 3-D models. Image-based face modelling considers facial textures (i.e., pixel intensities) as critical clues and estimates 3-D face shapes and surface reactance properties by reversing image formation processes.

Keywords*:* 3D images, Missing parts, ICP algorithm, Face mask

I. INTRODUCTION

Approaches to 3-D face modeling can be grouped as global (or holistic), and local (or region based): The former, perform face matching based on representations extracted from the whole face; The latter partition the surface into regions, and extract and match appropriate descriptors for each of them. Combinations of solutions in these two categories are also possible as well as multimodal approaches that combine together 2-D and 3-D methods.

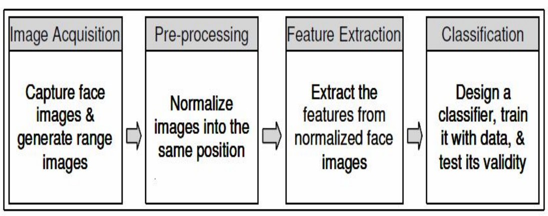

Figure 1.1: Block diagram of a face recognition system

3-D face recognition solutions that have been demonstrated and evaluated using facial scans with missing parts. In doing so, it should be noticed that facial scans with missing parts can be obtained either by removal of some parts from frontal scans, or through the acquisition of scans from nonfrontal views of the face. In the latter case the recognition problem is further complicated by artifacts that alter the geometry of the acquired 3-D surface in correspondence to the borders of the missing regions. Actually, only a few face databases have been constructed that make available partial acquisitions of 3-D face scans. Global 3-D face representations for partial face matching have been demonstrated in a limited number of works. A canonical representation of the face is that which exploits the isometry invariance of the face surface to manage missing data obtained by randomly removing areas from frontal face scans. There are a lot of face recognition algorithms, along with modifications, have been developed during the past few years. Most number of complex algorithms are presented, being distinguished into appearance based and model schemes. For appearance-based methods, three linear subspace analysis schemes are presented, and several non-linear analysis approaches for face recognition are briefly explained. The overview of using a mask for registration in a face recognition system is not new.

II. BASIC TERMS

A. Keypoints of depth images

The first step of the given approach is prior to the detection of keypoints; the 3-D scans are rigid 3-D transformation (rotation and translation) so as to normalize their pose to a common reference frame. This is a nontrivial problem by itself, and several approaches have been recently reported for the specific domain of 3-D faces [3]. Therefore, rely on existing methods to derive a few landmarks of the face that are detectable with a good accuracy also in acquisitions with large pose variations (up to about 70/80 degrees), and use them to perform face alignment. This is accomplished by computing the 3-D rotation and translation transform that minimizes the mean Euclidean distance of corresponding landmarks. The used landmarks are, namely, the nose tip, the inner and outer eye corners, and the mouth corners. The approach works on points clouds and is robust to rotation, translation, holes and outliers. In order to remove points that do not belong to the face, the nose tip is also used as center of a sphere of points that fall within a distance of 100 mm, leaving out all the points exceeding this radius (an absolute distance is used in that actual measures of the face size are important to discriminate between different face images). Proportions of the face are then used to select the regions that correspond to the searched landmarks. These techniques can be easily implemented and enable the extraction of facial landmarks with low computational cost (i.e., less than 2 seconds are required to extract the landmarks on a Centrino Duo 2.2 GHZ CPU, with 2 GB memory). Once the landmarks are detected and used for initializing the alignment process, the pose of the 3-D faces is then refined according to a rigid transformation using the ICP algorithm. In this way, 3-D points are registered with respect to a reference model obtained by averaging a selected set of FRGC v1.0 scans with neutral expression and frontal pose. As a result, the acquired scans are normalized to a common pose and depth images of the face are extracted. Some further preprocessing steps are applied to the depth images before analyzing them for keypoints detection. These account for spikes removal using median filtering in the -coordinate, filling of small holes with cubic interpolation, and 3-D scans resampling on a uniform square grid at 0.7 mm resolution. The resulting depth images are used to extract face keypoints by running the SIFT keypoints detector. When applied to depth images, SIFT keypoints detect blobs of depth values, corresponding to scale-space extrema of the scale normalized difference of Gaussians operator. Since blobs in depth scans correspond to regions whose depth values differ compared to the surrounding, detected keypoints correspond to local protrusions/intrusions of the face surface. Depending on the scale of detection, the keypoints may correspond to major or minor protrusions: the nosel point of the nose, the chin, the cheeks are typically observed at a coarse scale, whereas at finer scales keypoints are localized in correspondence to folds, creases, ridges and grooves of the face. Face recognition based on the analysis of 3D scans has been an active research subject over the past years. then, the impact of the resolution of 3D scans on the recognition process has not been addressed explicitly yet being of primal importance after the introduction of a new generation of low cost 4D scanning devices. These devices are capable of combined depths acquisition over time with a low resolution compared to the 3D scanners typically used in 3D face recognition benchmarks. In this paper, we define a super-resolution model for 3D faces by which a sequence of low-resolution 3D scans can be processed to extract a higher resolution 3D face model, namely the *superface* model. The solution relies on the Scaled ICP procedure to align the low-resolution 3D models with each other and estimate the value of the high-resolution 3D model based on the statistics of values of the low resolution scans in corresponding points.

Figure 2.1: Facial scan

B. Keypoints Clustering

Detected keypoints distribute irregularly over the face surface: in some parts of the face they are more densely distributed than in other parts. Aggregates of close keypoints usually occur in correspondence to regions of the face surface characterized by high spatial frequency components typically due to facial wrinkles in the mouth, eyes and nose regions [10]. In order to retain only the most stable, repetitive and informative keypoints, the set of detected keypoints is subject to clustering, according to the hierarchical clustering model.

C. Keypoints Repeatability

The idea to ground the face representation on a sparse and adaptive set of automatically detected keypoints relies on the assumption of intrasubject keypoints repeatability. Keypoints extracted from different facial scans of the same individual are expected to be located approximately in the same positions on the face. Since the localization of keypoints extracted by processing a face scan through the SIFT detector only depends on the geometry of the face surface, these keypoints are not guaranteed to correspond to specific meaningful landmarks of the face. For the same reason, the detection of keypoints on two face scans of the same individual should yield to the identification of the same points of the face, unless the shape of the face is altered by major occlusions or nonneutral facial expressions.

D. Facial curves

The information that is captured by SIFT descriptors of the keypoints is not discriminant enough to support accurate recognition of the identity of the subject [11]. In the solution, additional information necessary to discriminate the identity of each subject is captured by considering facial curves extracted from pairs of keypoints.

III. OTHER TECHNIQUES OF FACE RECOGNITION

A. Local Shape Difference Boosting

A new approach, called *Collective Shape Difference Classifier* (CSDC), is demonstrated to give the best result of the accuracy and computational efficiency of 3D face recognition. The CSDC learns the most discriminative local areas from the *Pure Shape Difference Map* (PSDM) and trains them as weak classifiers for assembling a collective strong classifier using the real-boosting approach. The PSDM is established between two 3D face models aligned by a posture normalization procedure based on facial features. The model posture is independent on others, which avoids registering the probe face against all different gallery face during the recognition, so that a high computational speed is obtained.

B. Accurate Landmarking

Three-dimensional face landmarking aims at automatically localizing facial landmarks and has a wide range of applications (e.g., face recognition, face image tracking, and facial feature analysis). The methods which are already present are assume neutral facial expressions and unoccluded faces.

C. Study of 3-D Face Recognition Under Expression Variations

Research in face recognition has been challenged by extrinsic (head pose, lighting conditions) and intrinsic (facial expression, aging) sources of variability. 3-D face databases with expressions are note down, and the most important ones are briefly presented and their complexity is quantified using the iterative closest point (ICP) baseline recognition algorithm. This allows ranking the databases according to their inherent difficulty for face-recognition tasks.

IV. RESEARCH DIRECTION

A. Study on 2-D and 3-D Face Recognition

Face recognition is the task of recognizing a person using digital face images. A face recognition system is typically designed to output a measure of similarity between two face images. Automated face recognition system is typically involve finding key facial landmarks (such as the center of the eyes) for alignment, normalizing the faces appearance, choosing an appropriate feature representation, learning discriminative feature combinations, and developing exact and scalable matching criterias.

B. Study on SIFT Keypoints

A Scale Invariant Feature Transform (SIFT) based local feature approach where sketches and digital images are matched directly using the gradient magnitude and orientation within a local region.

CONCLUSIONS AND FUTURE WORK

In this paper, we have described the range images have several advantages over other image data for face recognition. Range images are invariant to the change of illumination and color and also represent the 3D information of face surface. an original approach to 3-D face recognition which is capable of performing recognition of a probe 3-D face scan also in cases where just a part of the probe scan is available. The approach first uses the SIFT keypoints detection and description to identify and characterize keypoints on the depth image representation of a face.The occlusions in face image are not detected with this system. The database which is used in this system does not deals with 90 degree occlusion.

ACKNOWLEDGEMENT

We are thankful to all the personalities who helped us throughout this survey. We have done research in this area which gives future research direction for many researchers.

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