3D FACE RECOGNITION

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ABSTRACT

A proposal of an automatic modular 3D face recognition process is described in this paper. The input of this algorithm is a three-dimensional face scan and the result is, whether the user is recognized or not. The algorithm is developed, tested and evaluated on the Face Recognition Grand Challenge (FRGC) database. There are two fundamental face recognition algorithms exploited during the recognition pipeline – the eigenface method and the recognition using histogram-based features.

1 INTRODUCTION

The face recognition is one of the most used biometric techniques. In everyday life, we recognize other people by their faces. We are able to localize a face in a very large and complicated scene. Also the detection of anatomical features, like nose, eyes and mouth position within the face, does not make us any difficulties. Furthermore, we can recognize faces from various angles, even if face expressions are present or a part of a face is covered. Many activities that we are doing completely automatically with no effort become quite difficult if we try to describe this process mathematically.

2 PROPOSAL OF 3D FACE RECOGNITION METHOD

The system proposed in this paper contains of five modules serialized in the pipeline. The first module in the recognition process deals with detecting significant points on the face (landmarks), such as tip of the nose, inner corners of the eyes, outer corners of the nose and bridge of the nose.

The localization is based on the curvature analysis of the face surface [1]. At each point of the face surface, the two principal curvatures are calculated and the point is then classified as peak or pit. The tip of the nose is located as the point on the face surface with the highest density of peak-like points. Other landmarks are located in similar way.

In the second module of the recognition pipeline is the face rotated to a predefined position. An axis between the tip of the nose and the nasal bridge is used to compensate rotation around x and z axes and the reflection symmetry of the face defined by the y-z plane is used to compensate the rotation around y axis. Once the face is properly oriented and all the landmarks are detected, the first stage of the biometric recognition may begin. Landmarks, their mutual positions and curves on the face surface that connects the landmarks provide several measurable characteristics that can be used for classification of the face to the specific bin. Subsequent recognition is then performed only within the specific bin. This process is similar to the two-level fingerprint recognition, where the classification into arch, tended arch, loop, whorl or twin loop of the fingerprint pattern is performed first and then the recognition continues within the specified pattern type only.

2.1 COMPARISON MODULES

There are two face recognition methods in the comparison module of the recognition pipeline. The first is the eigenface method that uses the principal component analysis [2]. Each face can be presented as a vector or point within the face space. The vectors from the same class (same person) are situated close to each other, while the distances between the classes are greater. Consider the range image calculated from the 3D model with resolution 150x200 pixels. The size of the corresponding vector is 30 000 and the face space has 30 000 dimensions as well. Principal component analysis seeks for the directions in which data vary the most and only the n (for example 50) orthogonal principal components are selected. Face vector is then projected into the reduced n-dimensional space where the distance is calculated and score based on the calculated distance is returned.

The second method integrated in the comparison module is the 3D face recognition algorithm using histogram-based features [3]. The input of this method is also, like in case of the eigenface, the range image of the face. The face is then divided into m horizontal stripes and in each stripe is performed the division into n bins based on the z-coordinate values of the points. This process provides feature vector of size $m \cdot n$ that can be directly used for calculating distance between the template stored in the database and probe scan provided by some user.

It may be obvious that some components of the calculated feature vector have more discriminating potential, while other components may be strongly affected by facial expressions and it is desired not to rely on them too much. Therefore, the weighted distance between the feature vectors is used. The weight coefficients are discovered using genetic algorithm. Initial population consists of random vectors that represent the weight coefficient. In each step of the genetic algorithm the weights are randomly mutated and crossed. The evaluation of the candidate solutions is based on the equal error rate that the recognition procedure provides with the current candidate.

Both eigenface and histogram-based recognition algorithms take as an input the scan provided by the user and compare it to the template that is stored in the database. The output is a similarity score that indicates how similar the two feature vectors are and the result of the recognition process should be binary value indicating whether the user is recognized or not. Therefore it is necessary to combine and threshold the score. There are various options how to combine and calculate the final score. An ISO technical report Multi-modal and other multi-biometric fusion describe some of those [4].

3 ACHIEVED RESULTS

So far, the landmark detection algorithm, orientation normalization, extraction of facial curves and measuring the anatomical characteristics defined by the located landmarks is implemented.

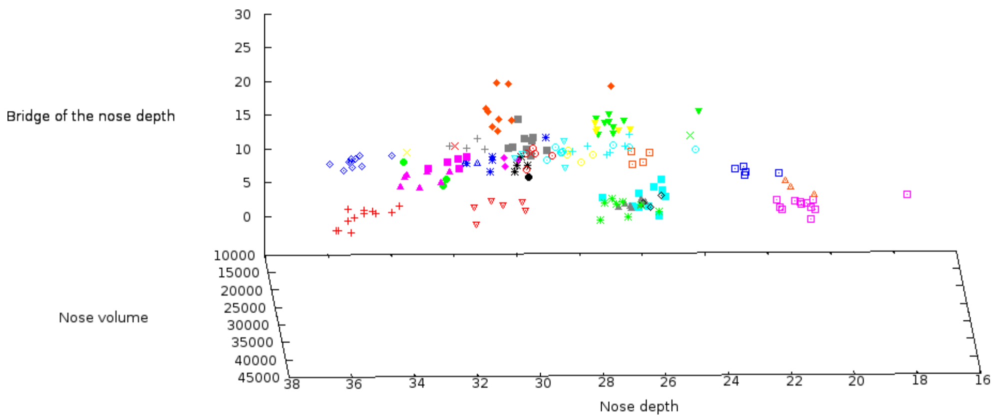

Figure 1: Clustering of the face space based on the selected anatomical features

The successful rate of proper landmark detection is 98% (tested on 1500 face scans).

The depth of the nose, depth of the bridge of the nose and the nose volume may be used as the dimensions of face space. 32 randomly selected persons and totally 172 face scans from the FRGC database [5] were selected and projected into the face space defined by the selected anatomical characteristics. It can be seen that the scans from the same person creates clusters (see Figure 1).

4 CONCLUSION AND FUTURE WORK

The next step in the recognition pipeline that has to be implemented is the comparison module and subsequent decision module. The goal of this thesis is the achievement of the lowest equal error rate (EER) value as possible. Therefore batch processing, final score combination and some optimization algorithms such as genetic algorithms described in the chapter 2.1 will be used in order to achieve better recognition performance.

REFERENCES

[1] M. P. Segundo, C. Queirolo, O. R. P. Bellon, and L. Silva. Automatic 3d facial segmentation and landmark detection. In *ICIAP '07: Proceedings of the 14th International Conference on Image Analysis and Processing*, pages 431–436, Washington, DC, USA, 2007. IEEE Computer Society.

[2] M. Turk and A. Pentland. Face recognition using eigenfaces. In *Proc. IEEE Conference on Computer Vision and Pattern Recognition*, pages 586–591, 1991.

[3] X. Zhou, H. Seibert, C. Busch, and W. Funk. A 3d face recognition algorithm using histogram-based features. *Eurographics Workshop on 3D Object Retrieval*, pages 65–71, 2008.

[4] Multi-modal and other multi-biometric fusion. Technical report, ISO/IEC, 2007.

[5] P. Jonathon Phillips, Patrick J. Flynn, Todd Scruggs, Kevin W. Bowyer, Jin Chang, Kevin Hoffman, Joe Marques, Jaesik Min, and William Worek. Overview of the face recognition grand challenge. pages 947–954, 2005.