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3D Face Modeling using Face Image

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Purpose It has been stated that patient satisfaction is the crucial factor for determining success in plastic surgery. The convergence of medical science and computer vision has made easier to satisfy patients who wants to have plastic surgery. In this paper, we try to apply 3D face modeling in plastic surgical area.

Materials and Methods The author introduces a method for accurate 3D face modeling techniques using a statistical model-based 3D face modeling approach in a mirror system.

Results We could successfully obtain highly accurate 3D face shape results.

Conclusion The method suggested could be used for acquiring 3D face models from 2D face image and the result obtained from this could be effectively used for plastic surgical areas.

Key Words 3D Face Modeling · Face Deformable Model · Face Shape Estimation · Statistical Face Model.

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Introduction

The big popularity of plastic surgery has created a booming plastic surgery industry. Due to the prevalence of plastic surgery, the importance of plastic surgery patients' satisfaction has been increasing. It has thus never been more important for plastic surgeons to rigorously measure and report on patient satisfaction and quality of life following aesthetic procedures. According to the study, among the patients who have had plastic surgery, nearly 20% of surgery patients reported their normal appearance altered in an unfavorable way. To remedy such problem, our study focuses on 3D face modeling. 3D face modeling can realistically express face deformation and pose variation with depth information. This method can generate highly accurate 3D facial shapes by using real 3D information calculated from the camera geometry. With these advantages, 3D face models can be applied to estimate plastic surgery result for patients. By calculating patients' 3D facial shapes after the surgery, it can be expected the rate of a failure of plastic surgery can decrease significantly (1, 2).

In this paper, we aim to develop a realistic 3D face modeling method that generates accurate 3D face modeling for plastic surgery results. First, we get 3D FSMs which are calculated from pre-defined feature points. Second, to get a detailed face shape, generic model fitting is performed. Finally, texture mapping is applied by stitching face parts. Thus, we can provide a 3D deformable face modeling to be used to preview the surgery result and be provided to plastic surgery patients.

Materials and Methods

To introduce the proposed system, Fig. 1 shows a workflow of the whole process in this paper.

3D Face Shape Estimation using Multi-view 3D FSMs in the Mirror System

A method proposed uses two mirrors on each side of the front face to overcome the lack of depth direction. Since synchronization problem may arise when using cameras, the mirror system was employed instead of adding the cameras.

A proposed method uses the pre-defined feature points. These points are used to calculate 3D coordinates by adjusting param-

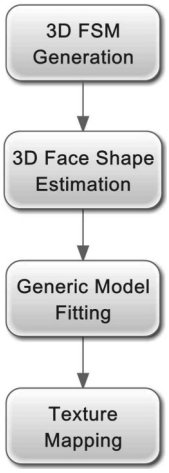

Fig. 1. Flow chart.

eters to match the landmarks of the 3D FSM with the extracted feature points.

Generic Model Fitting

After 3D face shape estimation, the 3D positions of other vertices can be determined by a generic 3D face model. The generic face model has been used in various applications since it has a uniform point distribution and provides a detailed face shape with a small number of points (3, 4, 5, 6). Among the previous approaches, radial basis function (RBF) is used in this paper.

Texture Map Generation using Modified Image Stitching Method

By stitching each face texture part, a texture map of the entire face can be created. A final face texture map is created. Fig. 2 shows the final 3D face after refining the texture map and the addition of artificial eyes.

To deal with a seam that appears on the boundaries, multi-resolution splining method is a generally used method. However its result is not satisfactory. Thus, the gradient domain image stitching method is used instead in this paper (7).

Results

We implemented Lin.'s method and calculated the 3D coordinates of the marked feature points. Then, we compared the accuracy of their method with that of our method. 3D procrustes analysis was used to align the 3D coordinates of the reconstructed points. After aligning the 3D points, we calculated the average sum of the Euclidean distances between each point on the reconstruction and the actual faces and 3D face modeling result is shown in Fig. 2 (8, 9).

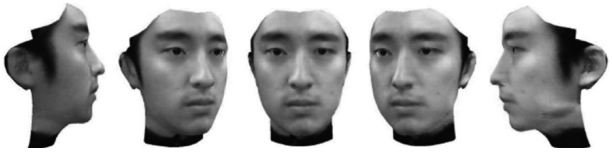

Fig. 2. 3D face modeling result after texture mapping.

Table 1. Absolute distance errors of the proposed and Lin.'s method compared to the actual faces

Estimation method	Absolute error (mm)		
	Mean	Std	Median
Lin.'s method (10)	3.12	1.14	2.59
Proposed method	3.58	0.59	3.49

Discussion

In our study, we introduced a method of 3D face modeling providing the advantage of plastic surgical areas. Using our proposed method, a well-developed 3D face modeling could provide valid assessment of individual patients' surgical result.

However, there is a room for improvement with respect to the absolute error as can be seen from Table 1. Thus, we plan to improve the weakness of the proposed algorithm in the future.

Conclusion

In this paper, we proposed a realistic 3D face modeling method that can accurately generate 3D face models. In the facial shape estimation procedure, we proposed a 3D face shape estimation method using multiple 3D face deformable models in a mirror system. In the texture mapping procedure, we applied cylindrical mapping and stitching technique to generate a texture map. The 3D face rendering results intuitively showed that out method is more robust to feature extraction errors than other 3D face shape estimation methods.

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