Facial Fattening and Slimming Simulation Considering Skull Structure

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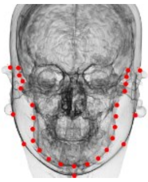

Figure 1. *Elucidated Skull*

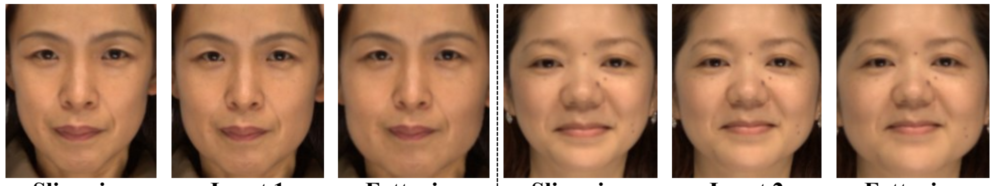

Figure 2. *Facial Fattening and Slimming Simulation Results*

1. Introduction

An accurate simulation of facial fattening or slimming is required in many areas, including beautification, health, and entertainment. [Blanz et al 1999] simulated facial fattening from a single image based on 3D morphable model. They fattened all faces in the same way considering only difference in facial surfaces; however, human face fattening depends on individual skull structure of the face. Further, without considering the skull structure, there is the possibility of deformed faces, for example facial surfaces penetrating into the underlying skull. Pei et al [2008] achieved accurate facial reconstruction that focused on the skull structure; i.e. the shapes of facial surfaces were determined primarily on the basis of skull structure. Therefore, considering skull structure is crucial for facial fattening.

In this paper, we propose a realistic facial fattening and slimming simulation method that uses a single frontal face image and is based on the skull structure of faces obtained from MRI images database. The advantages of our method are summarized as follows: reflects individuality based on the input's skull structure; prevents the facial surface from unnatural deformation; i.e. penetration into the skull.

2. Database Construction

We constructed a database consisting of 24 female frontal face images and corresponding MRI images. Subject ages ranged from early twenties to late forties. The maximum body mass index of these subjects was 25.0 and the minimum was 18.3. First, 86 feature points (FPs) were detected from the frontal face images via a face alignment technique [Irie et al 2011]. Here we normalized the scale, rotation and position of these data.

Second, the shapes of the skulls in the MRI images were elucidated (Fig.1), using a volume rendering technique [Kniss et al. 2002]. We manually extracted 23 FPs on the contour of skulls elucidated from the MRI images. We also extracted 7 FPs as fiducial points on the facial contour elucidated from the MRI images. These 30 (23 + 7) points were warped (as were the 7 fiducial points) to facial contour FPs of corresponding frontal face images. Furthermore, to estimate the input skull structure, the average of each of the 86 facial FPs and 23 contour FPs of the skull were calculated.

3. Facial Fattening Simulation

Our facial fattening simulation is performed as follows. First, we estimate the input's skull structure. 86 FPs are detected from an input image using Irie et al. [2011]. In addition, the average of skulls' contour FPs in the database is warped to match the input facial FPs via radial basis function (RBF) with correspondence between the average of faces in the database and the input facial FPs. Second, to calculate the individual facial fattening rule of the input from the facial contour FPs in the database, we warp them such that contour FPs of skull in the database are aligned to the estimated input's skull, all the while keeping the thickness of the fat layer. Facial FPs in the database are warped to match the estimated input's skull via RBF with correspondence between the contour FPs of skulls in the database and the estimated input's skull. Third, we apply principal component analysis (PCA) to two-dimensional coordinates of these warped facial contour FPs in the database and extract the individual facial fattening rule for the input. The difference in the amount of fat appears as the difference in each subject's facial contour FPs' coordinates with the skull aligned. We adopt first and second principal components as the facial fattening rule because we observed that first and second principal components fit the fattening rule and the cumulative contribution rate is over 80% (see Supplementary Supporting Document). Finally, the input's facial contour FPs are warped using our facial fattening rule. We constrain the facial contour FPs to refrain from penetrating into the skull.

4. Results and Discussion

Results of fattened or slimmed faces simulated by our method are shown in Figure 2. From our results, we found that the contour of the cheek substantially moved, similar to real fattening. Moreover, facial contours of slimmed faces were stopped at the cheekbone and the jawbone due to the collision with the underlying skull.

Our approach did not focus on the change of shading depending on facial fattening or slimming. To solve this problem, we will apply our method to 3D models. It will increase the realism of our facial fattening and slimming simulation.

In the supplemental video, we present our contributions by comparing our results with that of previous work. Our results showed that our method simulated realistic facial fattening and slimming.

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SIGGRAPH 2014, August 10 – 14, 2014, Vancouver, British Columbia, Canada.

ACM 978-1-4503-2958-3/14/08

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