Principal Components Analysis of 3-D Scanned Human Heads (sap_0100)

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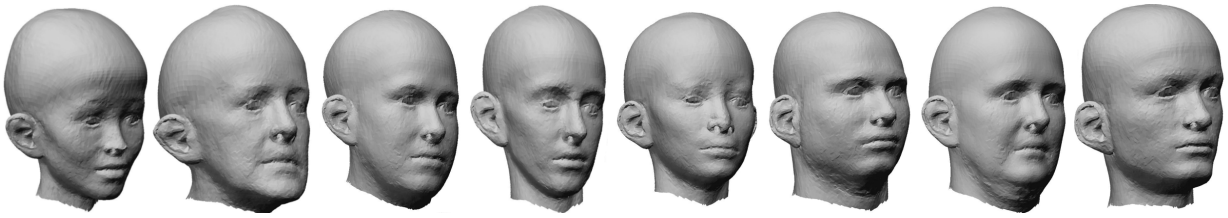

Figure 1: *Novel faces created from the CAESAR dataset*

1 Motivation

Modeling and creation of realistic human heads have applications in various domains, including computer animation, electronic games, virtual environment, film production, etc. Often the characters designed by artists are far from being human-like. In crowd simulation, characters tend to have the same or similar face appearances. In 3D games, it is important for users to have plenty of selections of 3D avatars. We explore an approach, which makes use of 3D scans of real persons to reconstruct countless new faces. The reconstructed faces based on principal components analysis have differences in ethnicity, gender, face shape, height and weight.

2 Overview

We conduct a complete analysis of human head variations over ethnicities and genders using principal components analysis (PCA). Principal components of aligned 3D heads represent the most influential differences in the dataset. The main elements of our work include (i) an improved method for consistent parameterization of a set of body scans; (ii) a method for aligning the heads with the aid of randomly selected markers; (iii) PCA analysis of the human faces in certain categories (ethnicities and genders); and (iv) visualizing the change of faces by animating along the main modes of variation. Our experiments are based on the Civilian American and European Surface Anthropometry Resource (CAESAR) dataset, which consists of about 5000 full-length body scans.

We start with consistently representing the models in the dataset by fitting a generic human model to each scan. We improve previous work [Allen et al. 2003] by using radial basis functions for initial fitting. This reduces the fitting time by half and simplifies the weight selection.

While the analysis method is applicable to the whole body, we concentrate on the human heads in this work since the shape variation in the face is the richest and most informative among the human body parts. As a result of the parameterization, segmentation of one model applies to other ones. Random selection of 51 markers from the generic head mesh and minimization of the distances to corresponding markers on instance meshes remove the variance in head pose and position, and thus make shape variances prominent.

Our analysis on the first twenty principal components reveals important information on the distribution of the human face in different ethnicities and genders. We analyze and compare Asians, Caucasians, and a mixture of people from these ethnicities. Similar variations among different ethnic groups are not able to hide certain interesting differences belonging to a specific group. This is also the case for male and female faces.

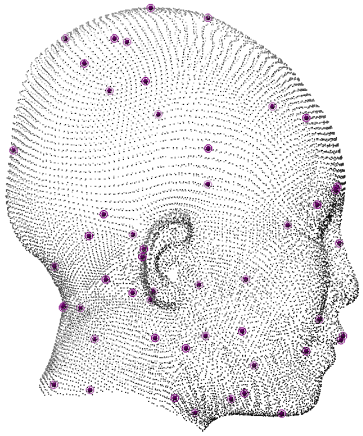

Figure 2: *Random marker selection from head mesh*

Our analysis predicts creations of countless number of new faces based on the current CAESAR dataset. For each component, we can have at least ten different faces and we observe significant variations up to the fiftieth component. The combination of such a wide selection along different components are able to create a huge number of heads with different appearances.

We demonstrate in Fig. 1 samples of our results, and in the supplemental video main variances along principal components in different ethnicities and genders. The faces that are created based on the analysis of the CAESAR dataset, as shown in Fig. 1, look like real human faces. In the supplemental video, the first part demonstrates the variations along certain principal components for Asians, Caucasians and the mixed ethnicities; the second part demonstrates variations along some principal components for males and females. Each row shows main mode of variation along some principal components in corresponding categories, and each face animation represents the variation along the corresponding component.

References

ALLEN, B., CURLESS, B., AND POPOVIC, Z. 2003. The space of human body shapes: reconstruction and parameterization from range scans. In *Proceedings of SIGGRAPH 2003*, ACM Press / ACM SIGGRAPH, Computer Graphics Proceedings, Annual Conference Series, ACM, 587–594.