Population-based Body Generation

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Introduction

Clothing production is targeted to a certain body. Here, the body used to mean a real human body. As clothing field is computerized, however, a body represented and displayed on the computer is gaining more significance. 3D scanning of human bodies and its various uses in clothing production are actively experimented [4]. Meanwhile, the capability – in this work we will call the technology realizing this capability as *digital clothing* – to construct a garment and preview various aspects of it on the computer before realizing it with real fabrics is also being exercised, in which a completely novel 3D character (contrasted from the 3D scan of a real human) can be the target of the clothing construction. This paper proposes a body generation technique in the context of digital clothing.

There are various modeling techniques which are developed for creating 3D geometries. But, those methods are targeted to professional animators, thus can require a large amount of work for a clothing expert to master the usage. In fact, even for trained animators, satisfactory modeling of a human-like body is not a trivial task. For the digital clothing technology to become a convenient tool to clothing experts, therefore, it is imperative to develop an effective framework for creating a desired human body with intuitive control. This paper proposes a body generation technique which is targeted to clothing experts (rather than 3D animators).

In this work, we propose a population-based optimization framework for human body generation. For generating a natural-looking human body, proposed method looks at the tendency residing in the given population and tries to generate a 3D human body which follows such tendency. For the control of the body shapes, we use the conventional body measurements (such as waist girth and stature) as the control parameters.

Characterization of Body Shape Variation

The judgment of human-likeliness of the generated shape is based on the range of shape variation in the given population. This work used the population included in the Civilian American and European Surface Anthropometry Resource Project (CAESAR) [2], which contains about 2,400 individuals along with the anthropometric landmarks.

Systematic handling of the population data calls for the establishment of correspondences across human bodies. The correspondences should be established for arbitrary points of the body surface. We call establishing the correspondence over the entire body as the *parameterization*. To this end, we adopt an optimization framework [1] for transforming a template body to a scanned body such that the topology of the mesh remains the same but its geometrical shape is deformed into the scanned body shape. For the parameterization of the population, we used the template mesh shown in Figure 1(a). Here, we manually placed the body landmarks on the template mesh. Then, we ran Allen et al.'s optimization technique [1] so that the template mesh is fitted to each individual in the population while constraining the body landmarks of the two bodies coincide each other. The landmark positions of the scanned body are used as a prior knowledge in establishing the correspondence. Figure 1(b) shows the results of the body transformation. We can observe that the transformed meshes closely resemble the scanned bodies in the geometrical shape, but the transformed bodies now have complete geometries (without any holes) with the correspondence established.

“Insert Graphic1 about here”
Figure 1: Body parameterization: (a) Template Body. Each green cone represents the position of the body landmarks. (b) The results of body transformation: the original scan bodies (top) and their transformed results (bottom).

To judge the plausibility of a shape, we extract the major shape variation components of each segment in the population by performing the principal component analysis (PCA). Through PCA, we can identify the most prominent and insignificant components of the shape variation. When the PCA components are identified, then the 3D mesh of a segment can be expressed in terms of a linear combination of the components. If the weights for prominent components are dominant then we conclude that the shape of the segment follows the general tendency in the population. If weights for insignificant components are large, however, we can conclude the segment is not plausible in that population.

Optimization-based Body Generation
Although PCA space is effective for identifying the principal components spanning the shape variation, in general the principal components are not in intuitive shapes. Therefore, generating a desired shape by taking a linear combination of the principal components is a non-trivial task. To overcome this limitation, we develop an optimization framework which establishes the relationship between the body measurements (intuitive control) and the PCA-based shape variation (non-intuitive but mathematically sound shape variation).

When the user needs to generate a new body, he/she just needs to specify the size constraints. Then, the proposed technique automatically generates optimally plausible body shapes from the parameterized population. The overall generation algorithm consists of two steps: 1) the system generates each segment of body independently, and 2) those segments are seamlessly joined according to another optimization process.

Results
Experiments were performed on the Windows XP environments. All computations are performed on Intel 2.4 GHz Core 2 Quad processors and 3.0 GB of memory. Our method was embodied with Visual C++ and visualized with OpenGL API.

In our experiments, 250 scan bodies are used to set up the shape variation space for each gender. Our implementation provide eleven size parameters, which consist of four length measures (stature, crotch height, arm length, and head length) and seven girth measures (head, bust, waist, bicep, wrist, knee, and ankle). The size control interface is implemented via the simple MFC user-interface as shown in Figure 2(a). A few results are depicted in Figure 2(b), which are automatically generated to meet the user-given sizes (Table 1). The average error in the realization of the size constraints is about 0.3 (cm).

Table 1: User-specified Size Constraints

(cm)	Stature	Crotch height	Head length	Arm length	Bust girth	Waist girth	Head girth	Bicep girth	Wrist girth	Knee girth	Ankle girth
Male 1	177.4	79.7	24.8	53.5	91.8	80.9	58.0	26.4	16.8	34.3	24.9
Male 2	184.5	83.0	25.2	55.2	128.3	87.7	59.7	33.8	20.8	38.1	27.4
Female 1	170.5	78.0	24.5	49.0	96.4	76.0	57.2	24.5	15.2	36.0	24.3
Female 2	171.0	78.5	24.5	49.0	120.8	121.0	62.3	35.1	19.1	43.8	29.3

"Insert Graphic2 about here"

Figure 2: (a) User-interface for the body generation. (b) Results of the body generation

Conclusion and Discussion

This paper presented a novel population-driven approach for body generation. The proposed method can easily create a plausible human body shape from user-given size constraints. As shown in the results, the proposed method produces natural-looking bodies. Controlling the body shape is intuitive, thus a clothing expert can use the technique without any prior knowledge.

During the experiments, we found out that the torso has the most complex shape variations. Realistic torso shape can make the whole body look more appealing. Generation of the torso from just a few sizes cannot cover the entire range of shape variation. The work proposed in [3] might be a effective way to complement the limitation of the technique proposed in this paper.

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