Garment Design System Based on Body Model

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***Abstract*—In this paper, we propose a garment design system based on a body model. Given a human body model, a user can specify range and distance functions over the body and arm axes by drawing a few strokes on the screen. The system then generates a garment based on these strokes. Various kinds of garments such as shirts, long and short pants, and dresses can be easily designed.**

I. Introduction

Garments are an important element of virtual humans. Garments must be designed for many applications such as computer animation, computer games, and digital fusion. Recently, not only professional creators but also casual users design garment models for their own avatars, which are used for on-line communication, producing animations for on-line video sharing, making custom figures for 3D printing, etc. However, conventional modeling systems are difficult to use. Designing garments is a time consuming task, even for professional creators. Although some sketch-based systems for designing garments have been proposed, they are for professional designers.

A garment is typically designed for a body model, so that it fits and covers the body. Our novel idea is to parameterize a garment shape using functions of the range and distance between the body and the garment along the axes. In this paper, we propose a garment design system based on a body model, as shown in Figure 1. Given a human body model, a user can specify range and distance functions over the body and arm axes by drawing a few strokes on the screen. The system then generates a garment based on the strokes. Various kinds of garments such as shirts, long and short pants, and dresses can be easily designed. We present some experimental results using our method, and discuss its effectiveness and limitations.

The remainder of this paper is organized as follows. Section II reviews related work. Sections III and IV describe our interface design and garment generation method, respectively. Section V shows our experimental results. Section VI concludes this paper.

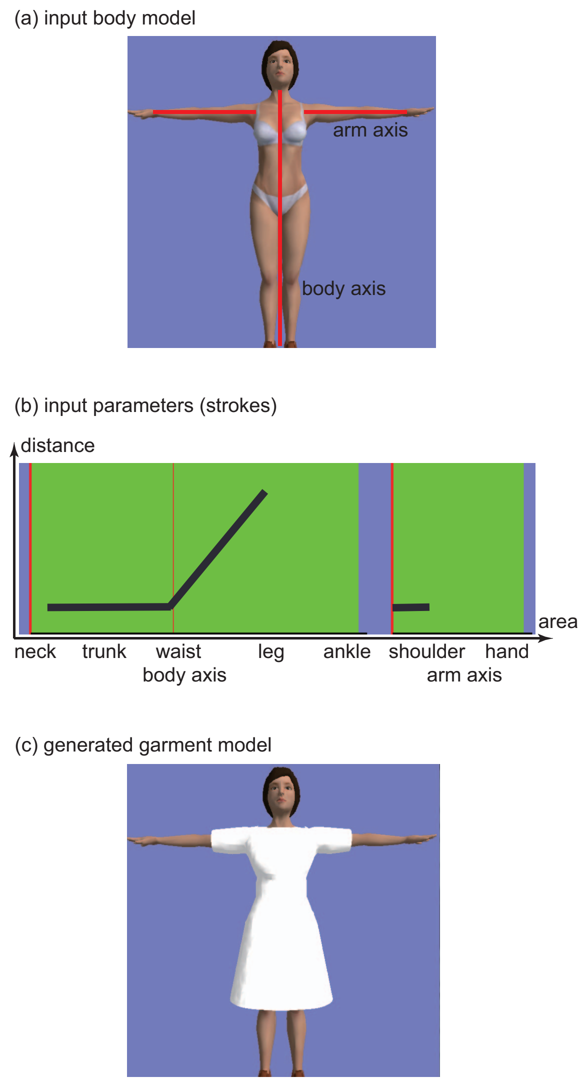

Fig. 1. Overview of the proposed method. A body model (a) and stokes on the 2-dimensional parameter space (b) are used to generate a garment (c).

II. Related Work

Designing garment models using conventional 3-dimensional modeling software is tedious. Sketch-based systems have been proposed [1], [2] as a solution to this problem. A garment model can be generated from one or a few 2-dimensional sketches of the garment. For example, Turquin et al. [2] proposed a method for generating a garment from two sketches (front and back). A garment sketch is a common tool used by professional designers. However, this is not easy for non-professional users.

Another approach is to create garments by designing patterns [3], [1], [4]. Real-world garments are produced by sewing 2-dimensional patterns. Given a set of patterns, a virtual garment model can be generated using a physics simulation. Umetani et al. [3] developed an interactive system that can be used to seamlessly design both the patterns and the resulting garment model. However, pattern design requires professional knowledge.

There are methods that deform a garment based on a body model [4], [5]. For example, Brouet et al. [4] proposed a method for deforming an existing garment model so that it fits a body model. However, their system requires a predefined garment model.

Several systems use a body model as a reference, so that a user can design garments based on the body model. Wibowo et al. [6] developed a system for designing a garment using a real mannequin by sketching the contours of a garment on it. Although the user can specify the area of the body, it is not easy to specify the distances between the garment and the body. Xu et al. [7] developed a system that designs the shape of a garment by editing the contours extracted from sections of the body model. With this system, the user must edit multiple contours of sections in 3-dimensional space. Unlike these methods, our system provides a simple interface so that a user can specify area and distance parameters on a 2-dimensional space.

III. Interface Design

This section describes the user interface of our system and how it generates garments.

The input to our system is a body model without a garment (a naked model). In addition to the geometry (polygon mesh) of the body, the axes of the body and arms must be specified, as shown in Figure 1(a). These axes are either manually specified by the designer or automatically derived from the bone structure (when the body is rigged with bones). The body model is supposed to be standing in a t stance, i.e. standing naturally with arms to the side, parallel to the ground.

A user of our system can design a garment by drawing strokes on the screen using a mouse, touch, or pen input device, as shown in Figure 1(b). The drawing area is divided into two parts: the body and arm axes. A stroke specifies the range of a piece of garment to be generated along the body and arm axes, in the x-axis of the input area. It also specifies the distance function between the body and garment surfaces, over the range of the y-axis of the input area. A stroke must not go backwards, that is, a stroke only has one distance value at each point over the range. This constraint is automatically applied when the user draws a stroke in the input area.

By drawing one or a few strokes, the range and distance parameters of a garment are specified and a garment model is generated immediately. Our system provides an interface for drawing, erasing, and updating strokes using a mouse, touch, or pen input device. A user can design garments quickly in an interactive way. Figure 1(c) shows an example of a generated garment.

Additionally, the user can specify either skirt or pants mode for the lower body. A different algorithm is applied to generate an appropriate garment based on the specified mode. The user can also choose the color and material for the garment. In our prototype, the user can select from a number of predefined colors and materials.

The user can design layers of multiple garments by repeating this process. When the user draws a stroke for a new additional garment, the constraint is automatically applied so that the new stroke (garment) does not penetrate into the existing strokes (garments).

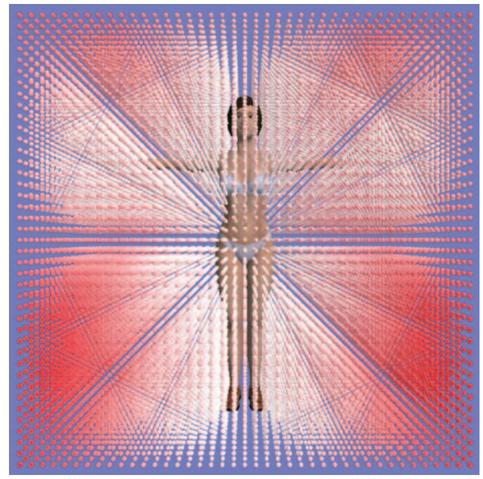

Fig. 2. Visualization of the 3-dimensional grids around the body model. The spheres represent grid modes. Their colors represent the distance to the body model (white is close and red is far).

Our system generates garment geometries for a given body in a given pose. Although animation of the generated garments is outside of the scope of this paper, conventional methods such as skinning and physics simulations [8] can be applied to the garment model.

Although our system is easy to use, it has limitations. Our system generates the overall shapes of garments. Details such as collars, frills, ribbons, pockets, and buttons cannot be created. However, it is possible to extend our system so that the user can select these details from a number of predefined models, and combine them with their garment model. Our system is also limited to symmetrical garments. Although most garments are symmetrical, there are non-symmetrical garments such as one shoulder dresses. It is possible to extend our system so that a user can make different strokes at several garment angles. However, the interface would become very complex and impractical. Since we did not enforce any constraints, a generated garment may penetrate into the body model or itself, especially when a large distance is specified. However, our system provides an interactive interface, so the user can tune the input parameters to avoid such penetrations. Although drapes cannot be generated by our system, they can be produced by applying cloth simulations to a generated garment [8], [1]. Despite these limitations, our method can effectively create the overall shapes of garments.

IV. Garment Generation

This section describes our garment generation method. A geometrical garment model (triangular mesh) is generated based on a set of given strokes. We use the marching cube method [9], which generates a surface that has a specified value (threshold) within a 3-dimensional space with continuously varying values. We use the distance to the body model as this value. Instead of using a constant threshold, we change the threshold based on the parameters (distance function) of the given strokes.

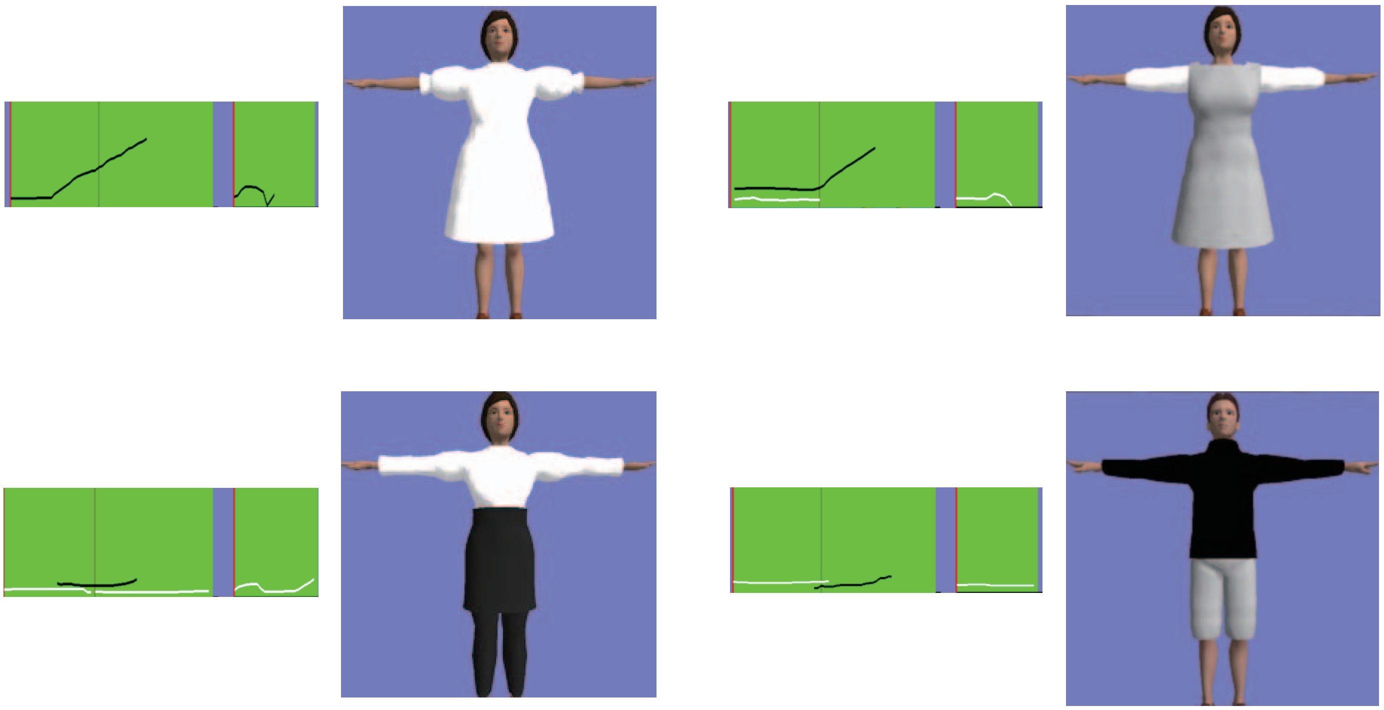

Fig. 4. Examples of generated garments. Input parameters (left) and generated garment models (right).

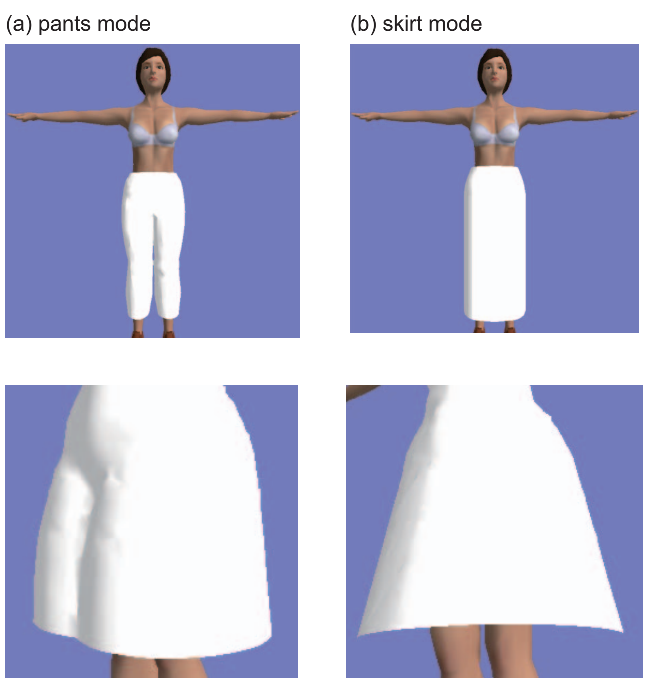

Fig. 3. Examples of garments generated using the skirt (a) and pants (b) modes with the same distance functions. The top examples used a small distance and the bottom examples used a large distance. Pants mode typically only uses small distances.

The 3-dimensional space around the body model is divided into 3-dimensional grids (see Figure 2). In our implementation, the size of each cell is set to 0.02 m. The threshold for generating the garment surface is determined for each cell. At each point of the body axis, the threshold is derived from the distance function (strokes). The same threshold is distributed to all cells on the hyperplane perpendicular to the body axis. If the distance function does not have a value on the body axis, no threshold is given to the cells on the hyperplane. As result, no garment surface is generated in these areas. The same process is applied to the arm axes. For each cell, we use the smallest threshold from the body and arm axes.

The distance to the body surface is computed for each node of the grid (see Figure 2). As described in Section III, we can specify whether to generate a skirt or pants for each stroke. When skirt mode is selected, the lower body model is replaced with a cylinder, which is generated by extending the contour of the hip toward the feet. The lower body garment is generated based on the distance to the cylinder, instead of the body model. As result, the shape of the cross section becomes elliptic instead of hyperbolic, as expected for a skirt-like shape (see Figure 3). We introduced skirt mode because the generated garment has unnatural folds if we always use the distance to the body model, as shown in the bottom-left image in Figure 3.

V. Results

We generated various garments using our system. Some examples are shown in Figure 4. One or a few layers of garments were created for each example. Each garment only took a few minutes to generate.

As an experiment, we tried to reproduce the garments of characters from some animes and comics. These characters often wear unique costumes that are different from ordinary garments. As explained in Section III, details such as drapes, collars, frills, ribbons, pockets, and buttons cannot be reproduced by this prototype. However, the overall shapes of garments and a few layers of garments were successfully reproduced. Thus, we believe that our method can effectively design initial garment shapes.

VI. Conclusion

In this paper, we proposed a garment design system based on a body model. Although the range of possible garments is limited, various kinds of garments such as shirts, long and short pants, and dresses can be easily designed in an interactive way. Our approach should be useful to casual users who wish to design garment models for their own avatars. In the future, we intend to include additional functions for adding details (collar, frill, ribbon, pockets, button, etc.), extend the method to non-symmetric shapes, and combine the model with physics simulations to generate drapes, etc.

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