SIMULATION OF EXTRACTION OF DEVELOPMENT ELEVATIONS OF BODY SURFACE

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ABSTRACT

In this system, we simulate a virtual draping method system. Draping method system is one way to make a pattern. To simulate we use "cloth model" and "body model". For modeling cloth, we use the way of regarding it as continuum model and formulating it based on dynamics of elasticity. And we measure surface figure of real dummy body and make the body model. After that we fit a cloth model to geometry of body model, for the last time make patterns of "princess line skirt".

Keywords: *Draping method system, Simulation, Cloth model*

1. INTRODUCTION

In the present apparel business field, there are many fashion brands and they provide clothing of various quality and price. Consumers can choose among a wide range of clothing, but clothing is not always fit consumers needs or body shape. Production for each person is one of the key words of KANSEI engineering, but at present production of clothing considering personal body shape is not feasible because of cost and labor hour. Computer simulation is effective to product clothing for each person, and there have been many studies [1-6]. There have been computer aided clothing design methods for each person in which 3-dimensional body shape is measured and measured surface is developed into plane panels [7]. As the methods are different from that employed in the real world, it is necessary to establish original methods or procedures. There are two methods, "draping" and "drafting" to make pattern of clothing. The purpose of this study is to realize the draping method virtually in a computer [8]. We are attempting to model cloth and body and then to establish virtual

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draping method based on these models. It is expected that we will be able to design clothing for each person with the method utilizing conventional know-how.

2. CLOTH MODEL

2.1. Outline of the Cloth model

In this study, cloth is modeled as continuum and formulated based on the theory of elasticity [9].

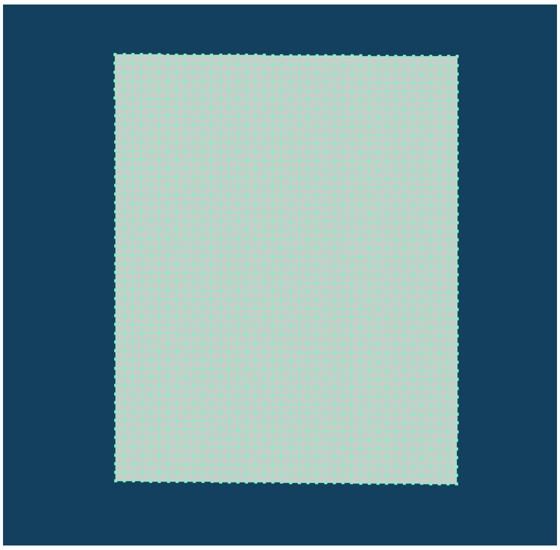

Figure 2.1: The Cloth model

A space coordinate is considered as a function of coordinate adhered to a cloth. The tensile, shearing and bending strains are defined based on the formulation. The cloth model is triangulated for numerical calculation. Strain is calculated from coordinate value of vertices of a triangular element. Specifically, tensile strain is calculated from three vertices of a triangular element. Bending strain is calculated from the three vertices of a triangular element and another three vertices of the triangular elements shearing a side of the former element.

Internal energy of a cloth model is expressed as quadratic form of strains. From differentiating it, the force acting on each vertex of triangular element is calculated. The minimum-energy state is considered as equilibrium state of the cloth model. Internal energy of a cloth model is obtained with an optimization technique [9]. In this study, a static simulation method is employed.

The space coordinate is defined as a function of the two dimensional curvilinear coordinate adhered on cloth. The coordinates on the cloth model is $(u \quad v)$, and space coordinates is $(x \quad y \quad z)$. Strains are defined as

$$\varepsilon_u = \frac{1}{2}\left(r_u^{\ 2} - 1\right)$$
$$\varepsilon_v = \frac{1}{2}\left(r_v^{\ 2} - 1\right)$$
$$\varepsilon_{uv} = \left(r_u \quad r_v\right) \qquad (2\text{-}1)$$
$$\kappa_u = -\left(r_{uu} \quad \omega\right)$$
$$\kappa_v = -\left(r_{vv} \quad \omega\right)$$
$$\kappa_{uv} = -\left(r_{uv} + r_{vu} \quad \omega\right)$$

where ε represents tensile or shearing strain, and κ represents bending strain. ε u is derivative of ε in u direction. Potential energy ($\underline{U}$) is calculated by expression (2-2).

$$\begin{aligned} \underline{U} &= \iint \left(\frac{1}{2}\{?\}^t A\{?\} + \frac{1}{2}\{?\}^t B\{?\} \right) dudv \\ &= \sum_i \left(\frac{1}{2}\{?_i\}^t A_i\{?_i\} + \frac{1}{2}\{?_i\} B\{?_i\} \right) \cdot S_i \end{aligned} \qquad (2\text{-}2)$$

The force exerted on each vertex of a triangular element is obtained as partial derivative of potential energy. The first term of the equation is tensile and shearing energy, and the force caused by tensile and shearing is derived from directional derivative of the term. The second term of the equation is bending energy, and the force caused by bending deformation is derived from directional derivative of the term.

3. VIRTUAL DUMMY BODY MODEL

3.1. Outline of Virtual dummy body model

In this system, virtual draping method is simulated. For the system, a virtual dummy body model (body model) is utilized for base of draping. It is made from measured three dimensional surface data of real dummy body. The measured data consists of a number of horizontal cross-sections (contours). A perpendicular central axis of the dummy body is defined, and each horizontal cross-section shape is made of 256 points of equal angular interval on the contour.

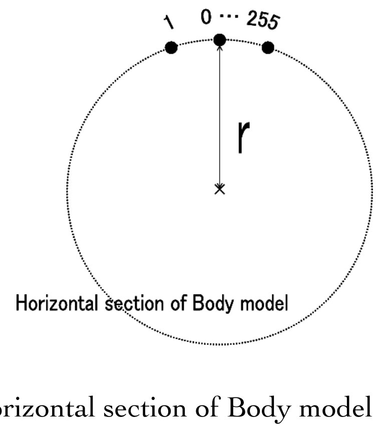

Figure 3.1: Horizontal section of Body model and Points on it

Figure 3.2: the Body model

3.2. Collision detection and reaction

To prevent the cloth model from coming into inside of the virtual dummy body model, it is necessary to detect collision between the cloth model and the body model and to define reaction. First, a horizontal cross section is picked up the height of which is equal to the height of a point on the cloth model. If the height is less than minimum value or more than maximal value of horizontal cross section's height, a point on the cloth model is exempt from collision detection. Then among the points of equal angular interval on the contour, the point of the direction from the perpendicular central axis is equal to a point on the cloth model is selected. Then, the distance between the central axis of horizontal cross section and a point on the cloth model is calculated. If it is less than a distance between the central axis and a point on the body model surface, it is judged that the cloth model collide with the body model. When the cloth model collides with the body model, the colliding point of the cloth model is moved to the point on the cloth model surface in the direction from the central axis.

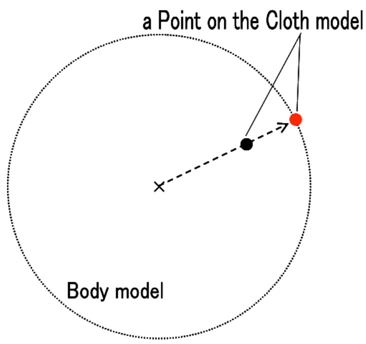

Figure 3.3: Collision reaction

4. CLOTH MODEL OPERATION

4.1. Outline of Cloth model operation

The purpose of this study is to recreate real draping method in a computer. Draping method is one of the methods to make a pattern. First, seams are drawn on the dummy body surface and cloth is pinned and fitted along a dummy body. When cloth is fitted to a dummy body, it is necessary to adjust warp line to a seam. Seams are mapped on cloth and the cloth is cut along the mapped seams to determine the shape of a pattern.

Here, the patterns of "princess line skirt" were virtually made using the cloth model and waist-down body model. At first, seams were drawn on the surface of body mode. This skirt consists of eight parts, and seams are two center lines of front and back of the body and two side lines of left and right of the body and four lines between those lines.

4.2. Mapping and a Steady state of cloth model

A rectangular piece of cloth model was created the width of which is wider than the distance between two neighboring seams, and it was mapped between the two seams on the dummy body. Grid nodes were put inside of the cloth model. Nodes on a column of the grid were mapped on one of the seams of the part of the skirt. Nodes on each row of the grid were mapped in the horizontal direction.

The cloth model in this state was deformed from the rest state. This state was utilized as the initial state of the mechanical calculation. During the mechanical calculation, attracting force to the direction to the perpendicular central axis was acted on every node. When the mechanical calculation was finished, the stable state of the cloth model was obtained.

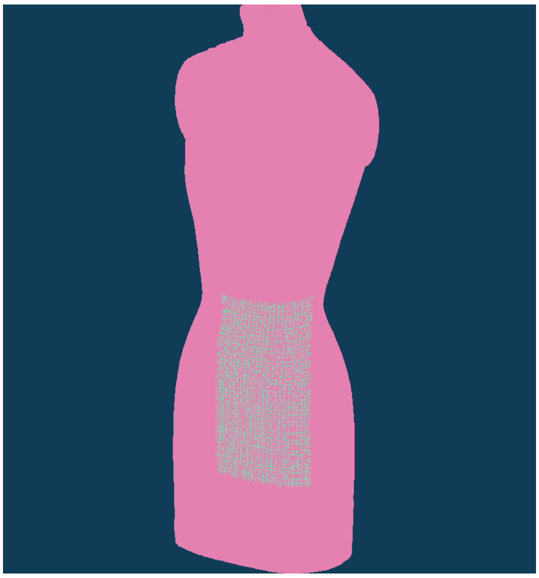

Figure 4.1: Mapping the Cloth model on the Body model

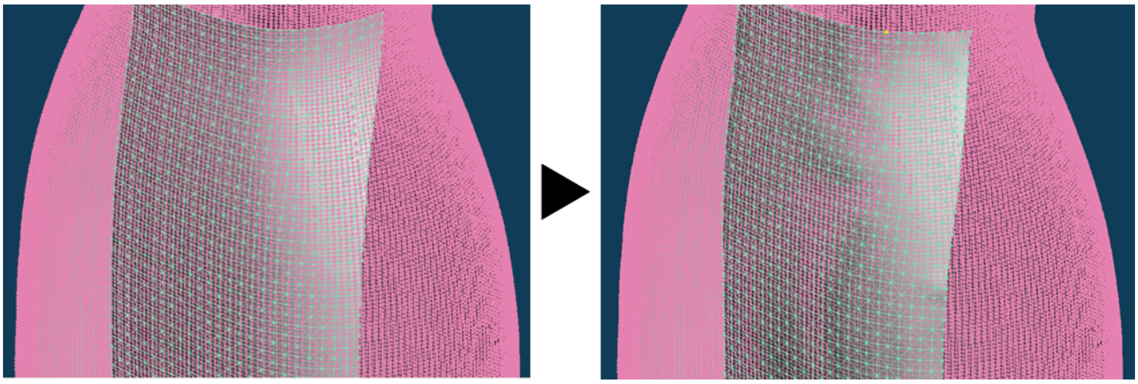

Figure 4.2: the Mapping Cloth model (left) and the Stable Cloth model (right)

4.3. Making a pattern

After the stable state was obtained, each part of the skirt which was separated with the seams was cut out of the rectangular cloth model as a pattern. Each node of the rectangular cloth model was determined whether it was in the area of a part of the skirt or not. The grid consisted of the nodes in the area was triangulated. The cut out figures in the rest state were regarded as the patterns of the skirt developed on a plane.

5. RESULTS AND DISCUSSIONS

The results are as shown in Figure 5.1, 5.2. The outline form of each pattern reflected the surface shape of the dummy body of each part. As the each pattern was created only from the nodes included in the part of the skirt, edge of the pattern was not smooth. To finish up a pattern, outline form of the pattern should be determined, nodes should be set on the outline form and triangular elements should be created to connect the grid nodes and the nodes on outline form. For example, the front-center and front-side patterns can not be joined together as they are shown in Figure 5.1. Then, the rough outline can be smoothed by connecting nodes at the stepped or concave corner by a straight line. Next, new node is set on the smoothed parts of the outline, and additional triangular elements are created to connect the new nodes and the preexistent node on the outline. It is necessary to even out the numbers of the nodes on the outline of the patterns joined together. Patterns of smoothed outline might be obtained by programming above-mentioned algorithm, to our system. The number of the nodes on the seams of different parts of the skirt should be the same.

Sometimes it may be necessary to adjust the shape of the patterns afterward they are created. To check the shape of the patterns, it is possible to predict the shape of clothing by mechanical calculation of virtual cloth panels sewn together. By checking the predicted shape of clothing, the pattern shape can be adjusted. Thus the draping processes in the real world can be virtually conducted.

As the clothing in this study has many seams, it was rather easy to fit the cloth model to the shape of the surface shape of the dummy body. But in general, various methods have to be required because it happens very often that the edge of cloth panel of clothing can't be fit to the dummy body surface. For this purpose, there is a huge problem left to handle such as development of interface.

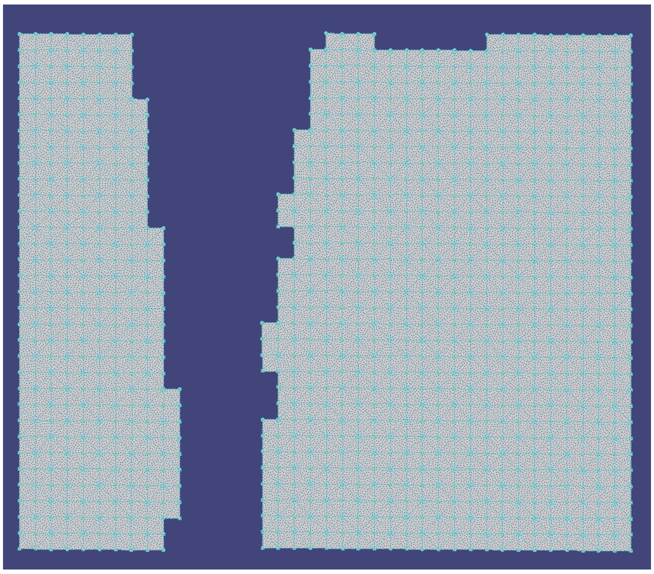

Figure 5.1: a Pattern of Princess line skirt (front-center and side)

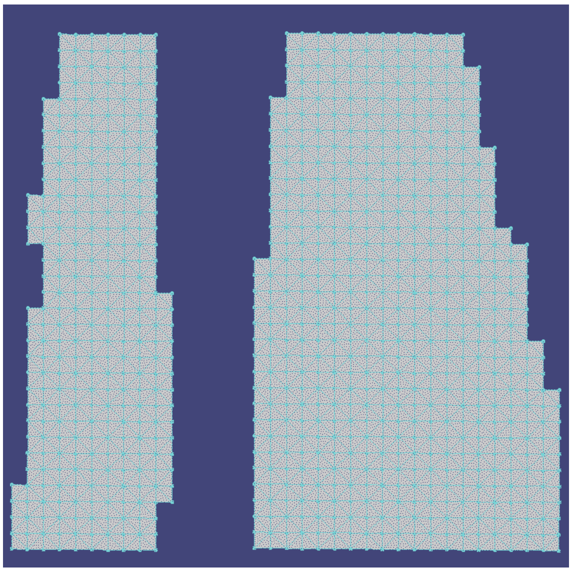

Figure 5.2: a Pattern of Princess line skirt (back-center and side)

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