Simulation of a Statically Draped Shape for Formation Capability with Given Number of Nodes

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Abstract

Many authors have predicted a three-dimensional shape of a garment when the mechanical properties of the cloth and the shape of the paper pattern are given as parameters.

In contrast, we tried to predict the parameters from a given shape of a garment. To simplify the problem, a statically draped shape was adopted as the given shape of the garment. Furthermore, for mechanical properties it was assumed that the bending stiffness is isotropic and that the other properties are constant. Due to these restrictions the unknowns of the prediction were reduce to two parameters : bending length and pendant length. The bending length is the cube root of bend rigidity divided by weight. Previous studies indicated that bending length is the most important material characteristic related to drape shape. The radius of the support stand was fixed, and 15 different bending lengths and 3 pendant lengths were used with reference to the values of real cloths. The initial shape with 3 different node numbers from 8,12,16 was used for the simulations (total, 135), and stability was evaluated for the number of nodes. The results confirmed the multi-stability phenomenon. The number of nodes, which is an important feature of a draped shape, was given and many simulations of statically draped shapes were executed with a wide variety of the two parameters. We were able to identify the domain of the parameters capable of forming each shape with its given number of nodes. However, in some areas, the capable domains for certain numbers of nodes overlapped with other domain. In addition, each capable domain was divided into two sub-domains by observation of whether the nodes were in contact with each other.

Keywords : apparel 3D design system, bending length, pendant length, drape shape, number of nodes, 3D drape simulation

1. Introduction

The massive exchange of information caused by the recent popularization of broadband internet environments has clearly become closely related to the lifestyles of people. This information technology has continuously created various products that were never seen before, and as computers became distributed to the general public, consumers have become able to easily make purchases through internet homepages. Accordingly, the greatest feature of modern life can be said the changing perspective in which to respond to the constantly changing, various products through information.

In response to these changes, there are several steps, including the single-direction step through product search via the internet and the dual-direction step in which the consumer participates in product development. In order to create clothing that accommodates these individualities, assertive user systems are being developed. Moreover, because high-tech information user systems through virtual reality technologies are being established, gradually an era of high-tech apparel 3D design system that responds to the individualities of each person through broadband internet is coming in the future.

Based on these technologies, there is a garment simulation that has already been developed.[1][2] This is a orthogenetic prediction system that shows the garment loading status according to the mechanical properties of the fabric[3] and paper patterns, in which the test garment can be checked. Though is a system developed to support clothing manufacturing, reverse apparel 3D design systems are more useful for consumer. In other words, automatic indication system is a method for inferring the cloth's mechanical properties and patterns using 3D images of the garment. It is critical to study and interpret this system.

This study address the issues of entering numerical value of the mechanical properties of the fabric that can be known only be experts as well as the issue with entering the numerical value for garment features, and is based on contributing to the high-tech apparel 3D design system development that categorizes the images of garments. The objectives are to make the mechanical properties of the fabric, in which its numerical values were entered using only keywords to make it searchable using shapes, to present the form's image in a short amount of time, and establish a system that displays the properties of the pattern and cloth by being selected by the user.

Because it is difficult at the current stage to directly establish the apparel 3D system, this study suggests garment imaging. In other words, representative drape shapes, in which the cloth's softness is considerably shown is proposed. At this time, for the paper pattern, the pendant length and the properties of the cloth were used as the estimate for the bend length.

There are many ways for classifying drape shapes, but for this, the number of nodes were observed for the visual features. When designating the number of nodes, as long as the drape length and bending length's range can be made clear for shaping the drape with the specific number of nodes, it will be very important for establishing the apparel 3D system.

Finally, when the designated number of nodes (n) are formed they are called 'has n-nodes formation capability', and when they are not formed, they are called 'does not have n-nodes formation capability'. In addition, when it has the ability to be n-nodes

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formation, the two forms in which the nodes are connected and when they are not connected should be taken into consideration.

For the three types of number of nodes, there were each 45 different types of simulations in order to classify n-nodes formation for each bending length and drapes for each number of nodes. In addition, for drape shapes, even for same drape lengths and bending lengths, there are multi-stabilities that stabilizes into various numbers of nodes.

2. Experimental

2-1 Materials

Using 15 types of bending lengths (0.55~6.42cm) extracted from 183 types of on-the-shelf fabric property ranges (chart 1), 3 types of drape lengths (20, 40, 60cm) and 3 types of number of nodes (8, 12, 16), they were combined and virtual sample simulations were conducted for 135 types.

2-2 Drape Shape Setting

Tests for this study are 3D simulation experiments. Drapes include static drapes in stop position and dynamic drapes in active position, but in this study, it is based on the first. Some mechanical factors of drape shapes are bending stiffness, shearing rigidity and weight per unit area. Of these factors, the displayed bending length and number of drapes have a high correlation.[4] In addition, there is a tendency for the number of nodes to reduce the longer the bending length becomes.

Table１・Ranges of the mechanical properties of textile fabrics

Weight	Tensile Rigidity	Shearing Rigidity	Bending Rigidity
(N/m^2)	(N/m)	(N/m)	(Nm^2/m)
$(0.5\sim30)\times10^{-2}$	3.0~50	10~200	$(0.5\sim3.0)\times10^{-6}$

Table２・Bending length of the fifteen samples

Sample No.	Normalized Bending Rigidity (B/W cm^3)	Bending length (cm)
A	0.17	0.55
B	1.25	1.08
C	2.56	1.37
D	4.16	1.61
E	6.15	1.83
F	8.71	2.06
G	12.1	2.30
H	16.9	2.57
I	24.1	2.89
J	36.1	3.30
K	60.0	3.91
L	96.4	4.59
M	132	5.09
N	144	5.24
O	264	6.42

Bending rigidity is assumed to be isotropic as referred to the text. Normalized bending rigidity is defined as bending rigidity per weight.

The weight or range of bending stiffness (chart 1) for the 183 types of marketing fabrics were each divided into 10 equal parts. This data set was used to find the bending length through □B/W (B: bending stiffness. W: weight). The 11 bending lengths which are at the maximum and minimum values for calculation were designated as samples A~K (chart 2).

In addition, in order to clearly identify the contact and non-contact of has n-node formation, does not have or n-node formation capable domains, the bending length were expressed as samples L~O.

In the drape experiment method described in KSK 0115, a small degree of deformation near the outer periphery of the support stand will cause large changes in the overall shape. This small deformation is closely related to shearing properties. To minimize the effect of the shearing properties on drape shape, we employed a circular skirt shape with no cloth on top of the support stand. As a condition for removing the center of balance, it changes from a fixed end (softly touches the support stand) to the supported-end (simply touches the support stand). This is for minimizing the shearing rigidity effect on the drape shape at the support stand. In addition, for the form, the support stand radius (r) was fixed at 10cm and the drape length (L) was changed.

The physical properties of the samples used in the simulation include seven sections such as weight, tensile rigidity (vertical and horizontal), shearing rigidity, bending stiffness (vertical and horizontal) and torsional stiffness. Because bending stiffness can vary from normal to custom depending on the vertical, horizontal or bias direction, it was presumed as to be in the same direction for the sake of simplicity. Therefore, the item that changes is the bending length.

2-3 Prediction Algorithm

In order to predict the shape through calculations, rather than actually making the clothes, pre-information includes paper patterns, texture, human body and garments, but this information become a factor for changing the shape of the clothes. However, in this study, the human body and garment is disregarded and predictions are made on two factors: paper pattern and textiles. When comparing the clothing shape and paper pattern, the deformation between the distances is found. By implementing the mechanical properties of the fabric for the change, the stress can be found. When a magnetic contact is apparent, one thin elliptical body is created for one of the separated triangular factor, and the relationship of the two elliptical bodies are examined. When the elliptical body begins contact or intersection, the repulsive force at the intersecting point and the repulsive force at the center are taken into consideration. After reorganizing these forces the force for parallel movement of the elliptical body or a moment is given for revolving movement to repel it. The repulsive force at the summit of the triangle is dispersed. The point is moved and transformed based on this force. Once a balance for the general point is created, the shape is determined. The form is transformed in the order of stress to the amount of deformation, and this transformation is repeated until the stop conditions are reached.

2-4 Method for Giving Mechanical property

Drape shapes were created using the 3-dimensional prediction system. The initial shape was set as a circle and the partition was set at circumference direction 144 and radius direction 10. First of all, in order to create the initial shape for each number of nodes, the multi-stability of the drape shape was taken into consideration and weights were added in several places to conduct simulation experiments. The mechanical property data entered at this time was made constant regardless of the fabric. Afterwards, by dividing the weight of all the property matter number and standardizing, the weight was set at 1.0, the tensile rigidity (vertical and horizontal) at 1000,0 (cm), the shearing rigidity at

50.0 (cm), the bending stiffness (vertical and horizontal) at 5.0 (cm³), and the torsional stiffness was set at 2.5 (cm³). This is the average of the mechanical property of the marketing fabric, and in order to reduce the number of calculations for the simulation, the tensile and shear was set at a low amount. When a weight is added and calculations are performed, the hemline height gradually falls, and at a certain point, a magnetic contact occurs. The shape created at this time was set as the initial shape. Afterwards, that weight was taken away and the property data of the sample was actually added to continue the calculations. The property of the sample used in the simulation is as shown in item 7, which is identical with the initial shape, and only the weight and bending stiffness that is related to the bending length was set as the variable data. The torsional stiffness (B/W)/2, which was determined by the standardized bending stiffness (B/W) (chart 2) was reentered when entering the calculations.

2-5 Standards for Evaluating Shape Categories

The observations were made to determine whether n-node shape is apparent, not apparent or whether it is in contact with each other. Based on this standard and in order to make a safe estimate for the changes of the coordinates of each point (x, y, z), the maximum moving distance from after 100 repeats were selected for calculation. For the example of the nodes 8 drape shape, the larger number from the vertical axis movement distance and the number of repeats on the vertical axis were used for plotting (picture 1).

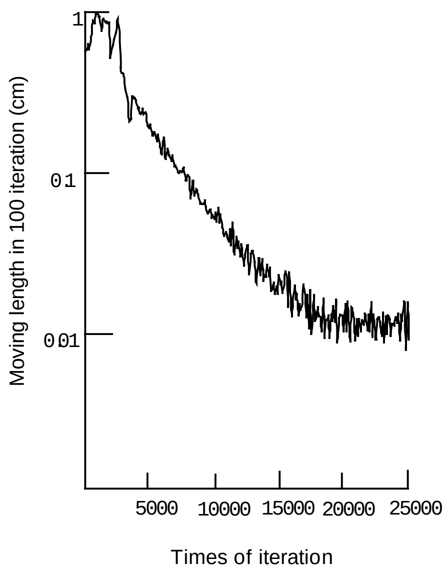

Fig.1 Logarithm of moving length in 100 iteration as a function of the times of iteration

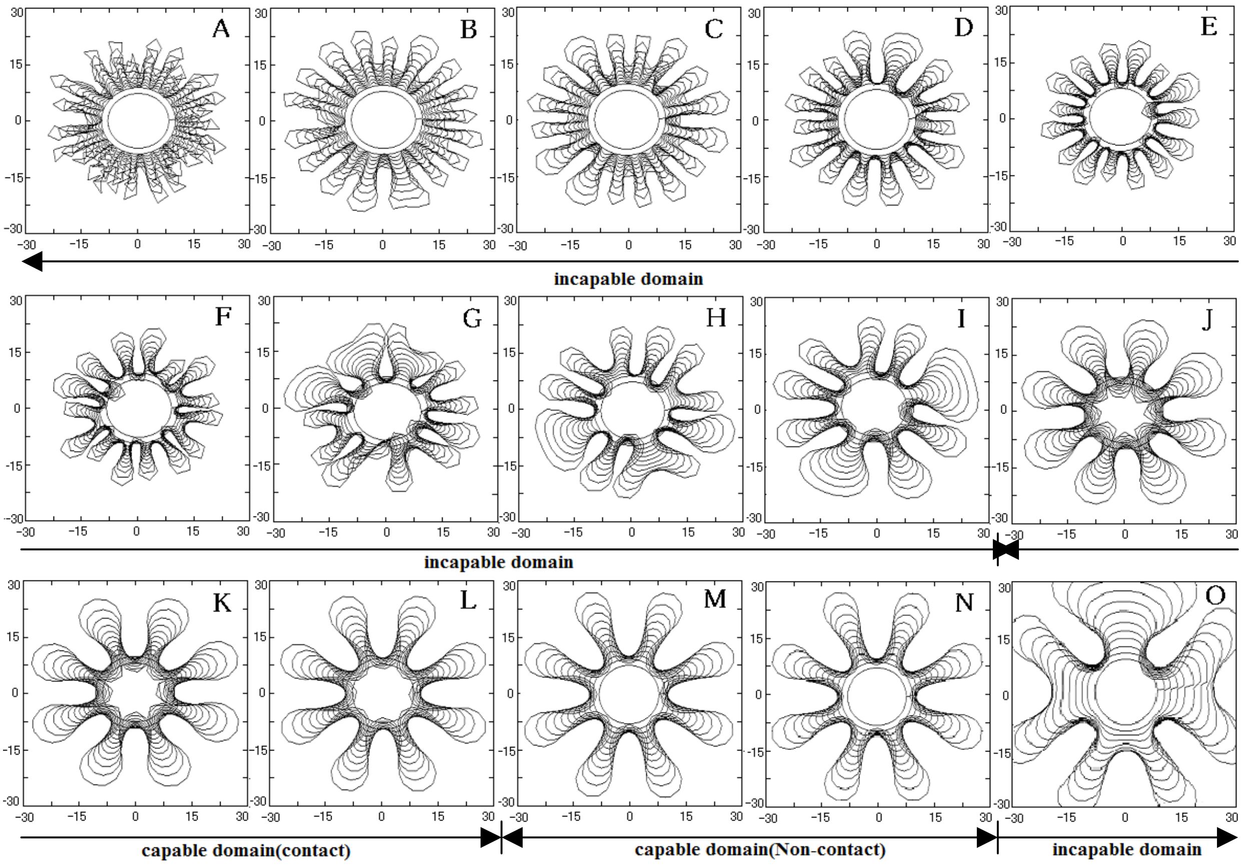

Fig.2 The shapes of draped hems observed from the base in the case of 5 nodes.
The symbols of A～O are referred to Table2, and the capabilities and properties

The larger number of the movement distance was reduced in a straight line, but it can be learned that there is almost no movement at 0.1mm. At this for time, for the stop condition, the maximum movement distance for 100 repeats were set under 0.1mm. It commonly contains this stop condition, but when it is ambiguous on whether n-nodes shape can be formed or not be formed, it was repeatedly calculated 30,000 times for safety, and the calculation time for the simulation had an average of 10 minutes for the SPECint_rate95 (456)

3. Results and Discussion

3-1 Evaluation of Formation with Given Number of Nodes

45 types of drape shapes were acquired for the 3 types of number of nodes that were calculated according to the simulation.

In picture 2, the node 8 bending length was changed and the prepared (with common stop conditions) drape shape reveals the general appearance of the below hemline shape. The drape shape in picture 2 can be changed in a variety of ways by entering the numerical value of mechanical property. The larger the bending length is set, the larger the drape area becomes. Also, the lower the drape length is set at, the smaller the drape area becomes and simultaneously, contact between nodes at a particular time. Following this, the shapes were distinguished by systematically investigations to fit the 20,000 additional stop conditions. Picture 2 is an example of a shape (picture 2-A~I, O) in which they are judged to have no n-nodes formation capability. When calculations are continued at this time, this example shows that 5-node shape is not possible for changes in the shape.

When the bending length becomes smaller (picture 2-I), the shape is destroyed when calculations are continued, and becomes a shape in which the given number of nodes cannot be acquired. On the other hand, when the bending length becomes longer in the shape (picture 2-O), and calculations continue, it is shown at a smaller number of nodes.

In addition, when it is distinguished to have n-nodes shaping, (picture 2-J~N), it is clear that there are 2 shapes to make one contact (picture 2-J~L) and that there is also one non-contact state (picture 2-M, N). In this shape, even when calculations continue, it is a shape in which node 8 is maintained. These results show the same shapes for the three types of number of nodes (8, 12, 16).

These results make it clear that the smaller the bending length becomes, the drape becomes excessively soft making it impossible to create number of nodes, and when the bending length becomes longer, the drape becomes excessively hard making it impossible to create number of nodes. These are the two types in which n-nodes shapes cannot be made.

3-2 Contact, Non-contact of Capable Domain

The 135 types of drape shapes acquired through simulations were classified as to determine whether the drape shape is stable at a particular node and whether the nodes are in contact with each other. These results were displayed in picture 3-a~c. In the picture, the 2 types of domains in which n-node shaping is possible and impossible are clearly classified by the contact or non-contact of the nodes. When comparing they are in which n-node shaping is possible shown in picture 3-a~c, the less number of nodes make the domain in which n-nodes shaping possible moves to the right (where the bending length is larger).

3-3 Capable Domain or Incapable Domain

Furthermore, the information on the domains in which n-node shaping is possible for each number of nodes was summed up and reorganized and displayed in picture 4. In result, it is clearly evident that there are 5 types of domains in which there are areas where n-nodes can be shaped for node number 8, 12 and 16. They are shown in detail in picture 4.

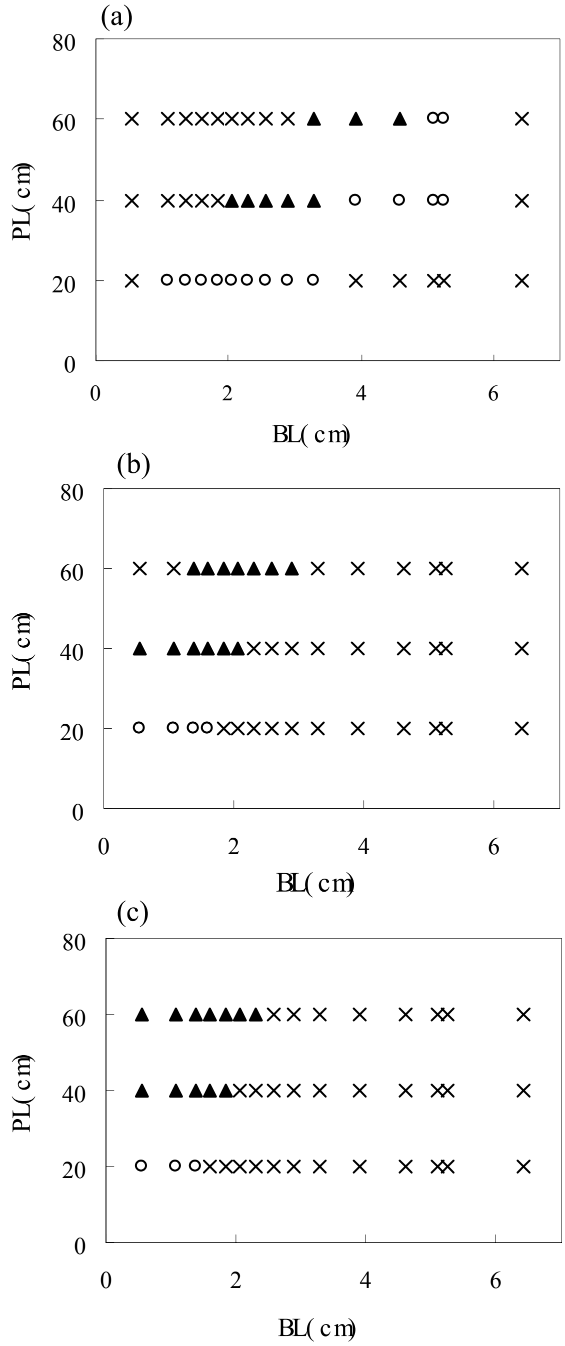

Fig.3 Classification of formation capability of nodes in the maps of the bending length (BL) and the drape length(L) with the symbols of classification being X(incapable),▲(contact) and ○(non-contact) ·
(a) : 8nodes, (b) : 12nodes, (c) : 16nodes,

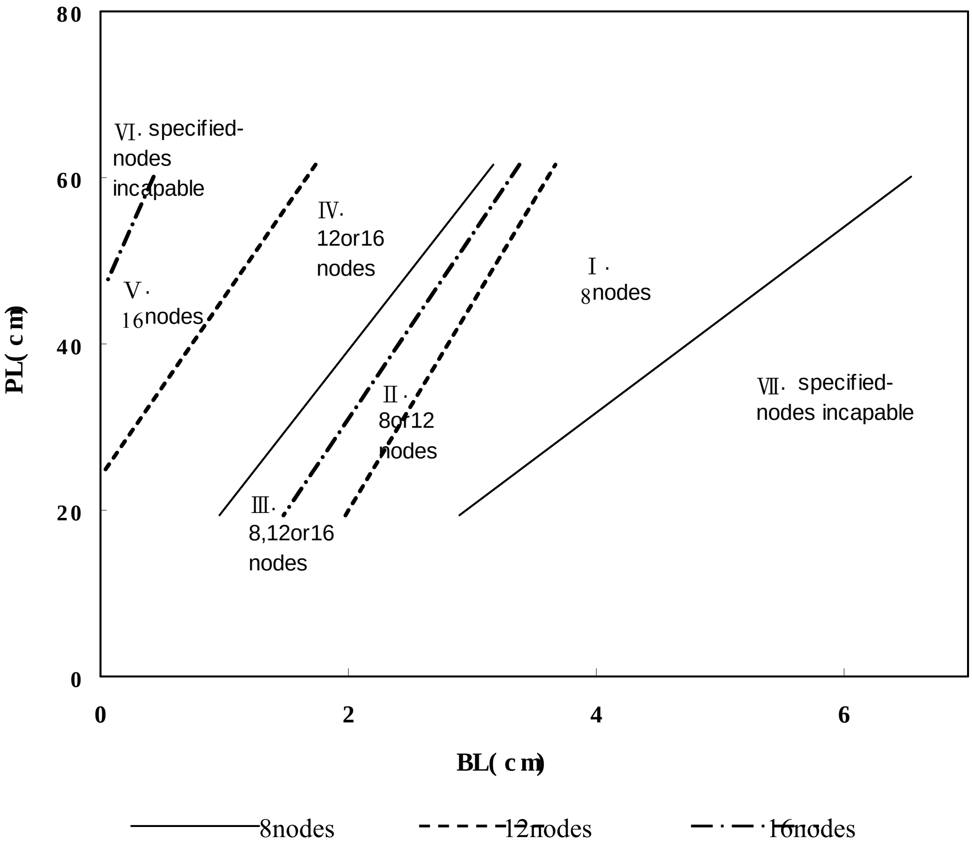

Fig.4 Domain of formation capability .
(Ⅰ)only 8 nodes capable domain,(Ⅱ)either 8 or 12 nodes capable domain,(Ⅲ)either 8,12 or 16 nodes capable domain,(Ⅳ)either 12,or 16 nodes capable domain,(Ⅴ)only 16 nodes capable domain, and (Ⅵ・Ⅶ) specified-nodes incapable domain.

4. Conclusion

In order to use the garment simulation design, multiple static drape shapes were simulated and they were classified depending on their node contact and non-contact status for those which can or cannot have n-node shapes for each bending length and drape length of their respective number of nodes.

(1) The contact and non-contact of nodes for the domains in which there are n-nodes formations or are possible for n-nodes formations for each bending length and drape length for their respective number of nodes can be classified.
(2) It is clear that the contact and non-contact of nodes for the two types of domains in which n-nodes formatting is impossible are separated.
(3) When the number of nodes are determined, the domain in which the n-nodes formatting is possible that responds to the number of nodes are predicted. This information is deemed to be very useful in constructing a more detailed apparel 3D system.

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