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Basic garment pattern generation using geometric modeling method

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Abstract

Purpose – The generation of individually fit basic garment pattern is one of the most important steps in the garment-manufacturing process. This paper seeks to present a new methodology to generate basic patterns of various sizes and styles using three-dimensional geometric modeling method.

Design/methodology/approach – The geometry of a garment is divided into fit zone and fashion zone. The geometry of fit zone is prepared from 3D body scan data and can be resized parametrically. The fashion zone is modeled using various parameters characterizing the aesthetic appearance of garments. Finally, the 3D garment model is projected into corresponding flat panels considering the physical properties of the base material as well as the producibility of the garment.

Findings – The main findings were geometric modeling and flat pattern generation method for various garments.

Originality/value – Parametrically deformable garment models enable the design of garments with various size and silhouette so that designers can obtain flat patterns of complex garments before actually making them. Also the number and direction of darts can be determined automatically considering the physical property of fabric.

Keywords Geometry, Modelling, Garment industry, Fashion design

Paper type Research paper

Introduction

Three-dimensional computer-aided design has become one of the most indispensable elements in modern industries. It is very difficult to find any design process that is not aided by CAD systems in traditional manufacturing processes of machinery, aircraft, and watercraft and most engineers take it for granted nowadays (Lee, 1999). Of course, such a trend is steadily spreading over garment industries. However, 2D CAD systems are still prevalent and therefore 3D design of garment is difficult. This is partly because of the difficulties in mathematical modeling of the fabric material that. However, a more significant problem is that designers and pattern makers do not think the CAD method to be better than the conventional manual method (Stjepanovic, 1995, Aldrich, 1992). Although such a phenomenon has always been with the initial development period of other purpose CAD systems, it is more serious as well as natural in garment industry because the quality evaluation of the product depends more on human aesthetic sense than on the optimum physical performance. Certainly, there are garments that need functionality more than the aesthetic appearance such as tight-fitting underwear or protective garments, CAD systems will be powerful tools in designing and manufacturing such mass-customized high-functional garments.

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There are two major basic pattern generation methods in conventional garment design. One is the flat pattern process, where patterns are designed two-dimensionally and the other is the 3D draping method, where a flat fabric is directly formed into a garment on a mannequin. Although it is more difficult to get garment patterns by the latter method, it is more appropriate to make well-fit patterns than the former method and recent studies on automatic pattern generation have focused on the latter method. In that case, some cut lines called as darts are necessary if the garment has undevelopable patches. McCartney *et al.* tried to develop 3D surfaces using darts and to implement such techniques into pattern generation (McCartney *et al.*, 1999; Collier and Collier, 1990; Heisey *et al.*, 1990a,b). However, full 3D human body data were not easily accessible then that it was difficult to make practical garment patterns. Recently, due to the advancement in non-contact measurement technology, 3D body data became affordable and many studies have been made on this topic (McCartney *et al.*, 2000; Daanen and Water, 1998; Au and Yuen, 1999; Paquette, 1996). Kim *et al.* tried to generate garment patterns by combining the 3D data of body and garment model. They also developed an interactive pattern design system using a parametrically deformable body model made from the 3D body scan data (Kim and Park, 2004; Kim and Kang, 2002). However, there have been some problems that it is difficult to get the ideal shape of garment by such methods and only the basic patterns can be obtained. In this study, a garment is divided into two zones, one for fit zone and the other for fashion zone. The fit zone is modeled by digitizing the body scan data so that it can provide optimum fit as well as the ideal shape of the garment. The fit zone can be reshaped and resized using basic anthropometric parameters that various sized fit zone can be modeled from a single body scan data. The fashion zone is modeled using parameters that determine the aesthetic appearance of the garment that users can design garments with various silhouette intuitively. Finally, a flat pattern projection algorithm was developed to make flat pattern pieces from three-dimensionally modeled garment considering the physical properties as well as the producibility of fabric.

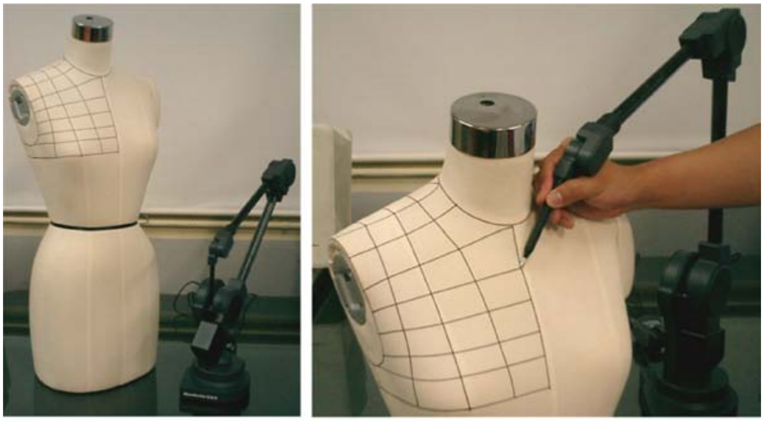
Fit zone modeling

Interactive modeling of fit zone from 3D body data

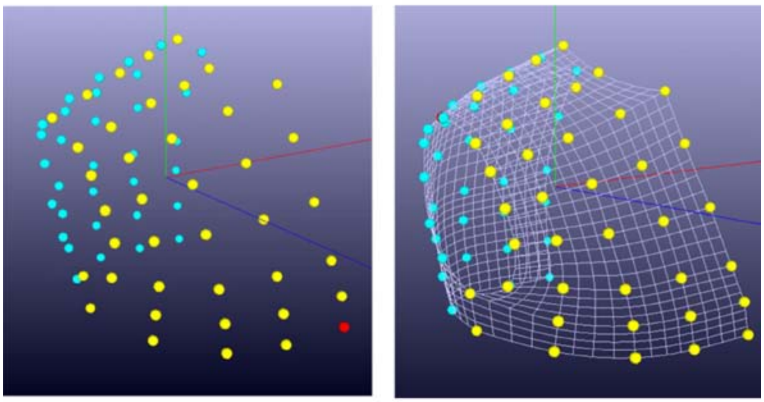
A garment can be divided into two zones to facilitate the 3D pattern generation. One is the fit zone, and the other is the fashion zone. The fit zone of a garment is in direct contact with the body surface and is responsible for the comfort of a garment that it must be designed to correctly reflect the shape of underlying body. In our previous research, the fit zone was modeled automatically from the body scan data, however, it was somewhat difficult to get a desirable shape of the fit zone with this method especially for slacks (Kim and Park, 2004; Kim and Kang, 2002). In this study, a fit zone was modeled by capturing and reconstructing the quadrilateral gird structure marked on the surface of a mannequin using a multi-joint coordinate measurement system as shown in Figure 1.

The surface model of a fit zone was constructed as a B-Spline surface taking the measured grid points as their control points as shown in Figure 2. The shape of fit zone was then refined to have a smooth shape by adjusting the position of each control point manually. Zebra striping technique was applied to verify the smoothness of the surface visually as shown in Figure 2.

Some examples of the fit zones prepared by this method are shown in Figure 3.



Mannequin and 3-D coordinate measurement system



Measured points and reconstructed B-Spline surface

Figure 1.
Schematic diagram of fit zone modeling

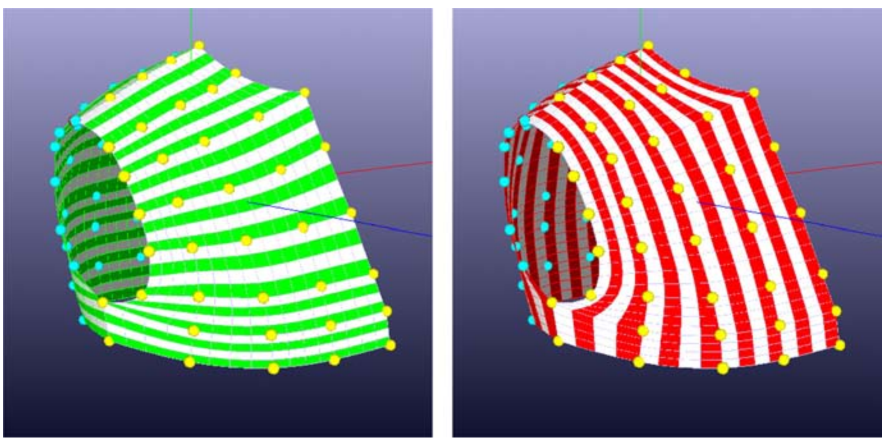


Figure 2.
B-Spline surface based fit-zone modeling

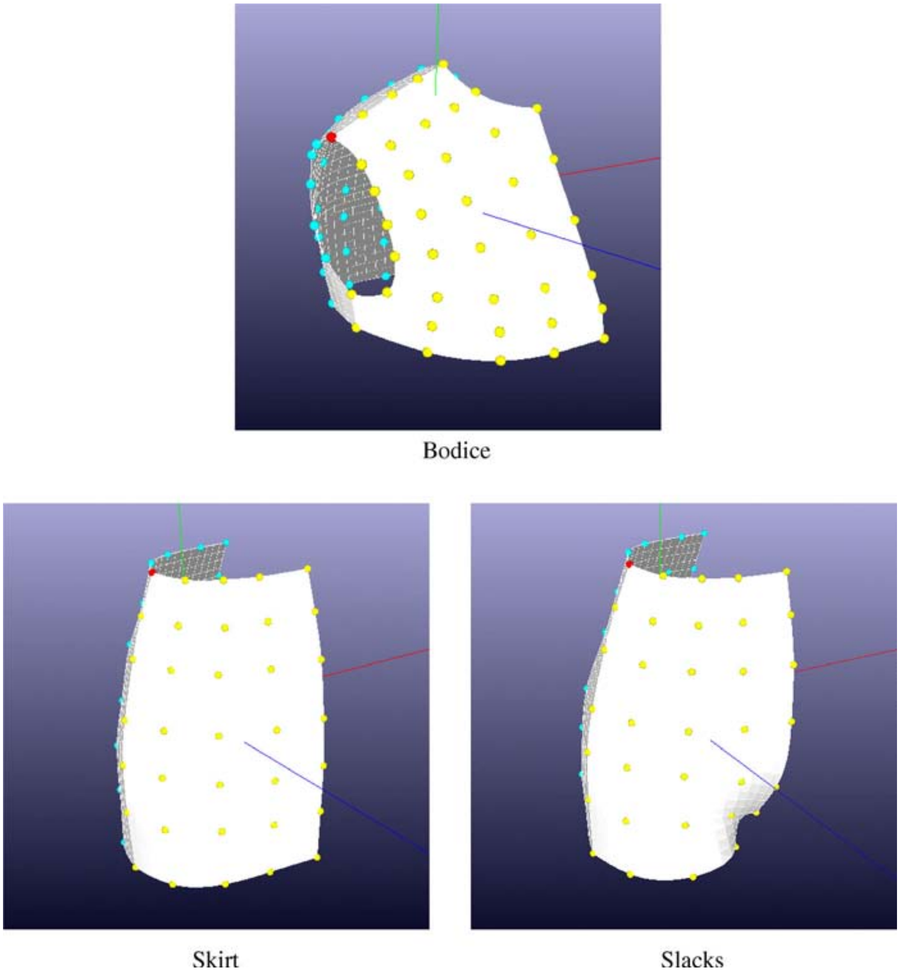


Figure 3.
Examples of fit zones

However, it is certainly meaningless to model the fit zone through the complicated method described above if it should be generated for each body scan data. Therefore, it is necessary to change the shape and size of the fit zone in a parametric way. The shape parameters of the fit zone defined in this study are listed in Table I.

The initial values for parameters in Table I are extracted from the originally obtained fit zone model. Then the original fit zone model is deformed according to the user-supplied parameters. The deformation of the fit zone is made by changing the height, the width, and the circumference of each key cross-section of the fit zone as shown in Figure 4.

Fashion zone modeling

The fashion zone of a garment is usually not in direct contact with the body but is draped freely to make the aesthetic appearance. The aesthetic appearance of a garment can be evaluated by many factors such as its overall silhouette or the number of folds at its bottom. In our previous research, only the tight fitting basic garments could be designed because the garment patterns were drawn directly on the surface of the body model. So far, costly trial-and-error methods have been used to obtain the desirable aesthetic appearance of a garment because it is very difficult to draw 2D patterns to accommodate to the shapes of imaginary 3D garments. In this study, the fashion zone of a garment is formed parametrically in 3D and projected into 2D pieces that complex patterns can be generated easily from the intuitive 3D previews. Parameters used to design the aesthetic appearance of a garment in this study are listed in Table II.

For example, the bottom shape of a skirt can be changed using two parameters including the number and amplitude of bottom fold. A sine curve of specific period and

Bodice		Skirt		Slacks	
Parameter	Default (in)	Parameter	Default (in)	Parameter	Default (in)
Bust girth	33.15	Waist girth	27.32	Waist girth	27.32
Front length girth	7.42	Abdomen girth	33.83	Abdomen	33.83
Neck girth	7.45	Hip girth	37.25	Hip girth	37.25
Side length	4.53	Skirt girth	37.36	Thigh girth	22.12
Armhole depth	4.89	Side length	13.30	Side length	13.30
Shoulder angle (°)	25				

Table I. Shape parameters for fit zones

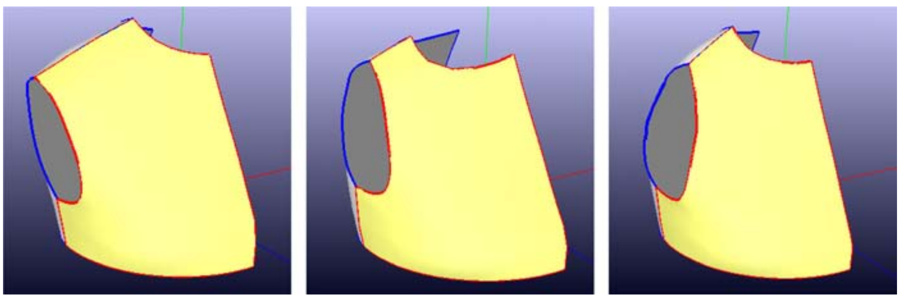


Figure 4. Parametric deformation of fit zone

Parameter	Default value Bodice	Skirt	Slacks
Height	6.97 in	11.8 in	27.5 in
Bottom width (percent)	80.0	90.0	80.0
Bottom depth (percent)	80.0	90.0	80.0
Front insert	0	0	
Side insert	0	0	
Bottom rounding	0	0	
Number of bottom fold	0	0	
Amplitude of bottom fold	0	0	

Table II. Shape parameters for fashion zones amplitude can be formed using two parameters as shown in Figure 5. Assuming the initial shape of a skirt to be an n-sided cylinder, the shape of its bottom edge can be modified by changing the distance between each edge and the centroid of bottom plane according to the amplitude of sine curve at corresponding angle. As the various 3D shapes of garments can be previewed easily in 3D with this method, it would be possible to obtain appropriate patterns for specific garment more easily.

Garments with various shapes can be designed easily by connecting the fit zone and fashion zone together as shown in Figure 6.

Flat pattern generation

A garment model usually consists of undevelopable surfaces that some cutting lines called the "darts" must be introduced to generate the flat patterns. In this study, darts are defined in either the lateral or the longitudinal direction of a pattern because those directions are approximately parallel to the major UV axes of the B-Spline surface of each pattern. In this method, darts are created along the mesh structure of the surface that it is easy to create as many darts as needed. This method seems acceptable because the darts are usually defined as such in the traditional manual pattern design method. Examples of the defined darts are shown in Figure 7.

The strain reduction method was used to flatten the patterns with darts. First, the mesh structure of each pattern was reorganized considering the darts and then projected onto the 2D plane. As each mesh element on a pattern undergoes a certain deformation during the projection, a considerable amount of strain is induced in the flattened pattern. An edge can be defined between every two node on the pattern as shown in Figure 8. By comparing and equalizing the lengths of corresponding edges in

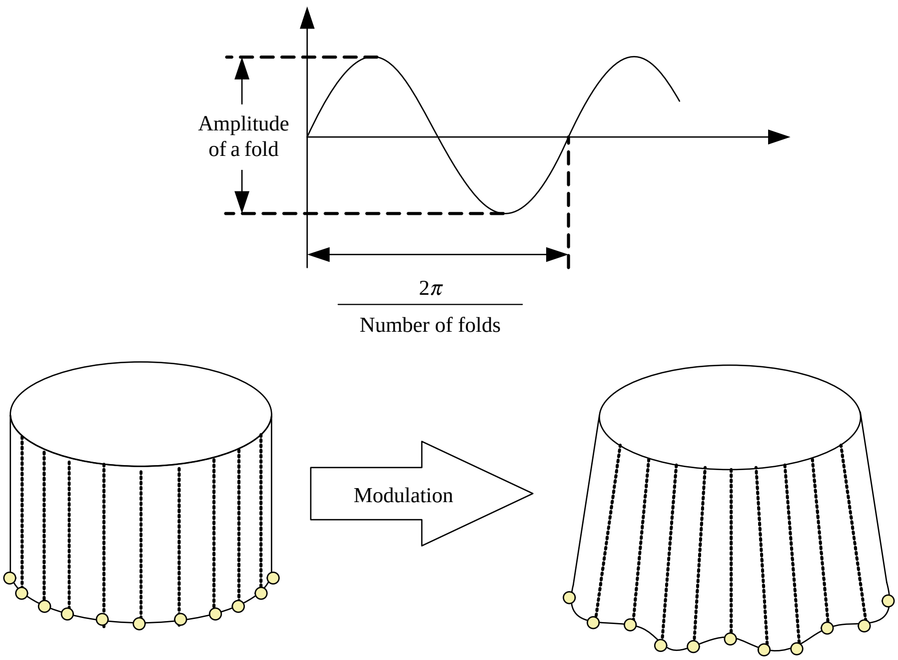


Figure 5.
Schematic diagram of fashion zone formation

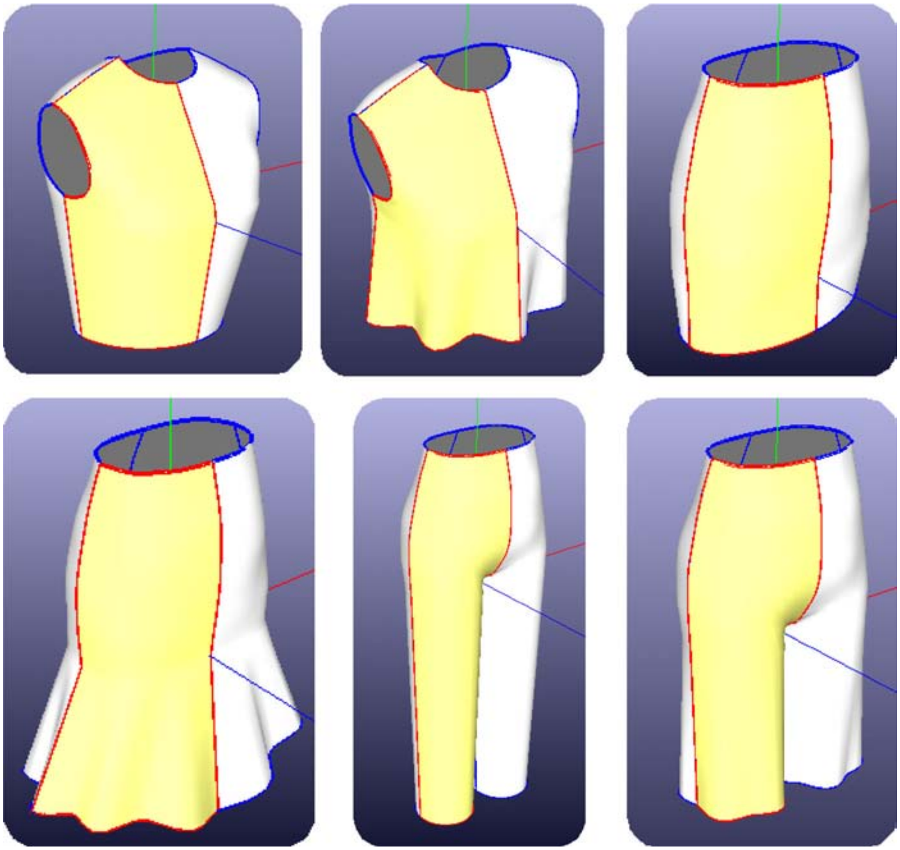


Figure 6. Examples of designed garments

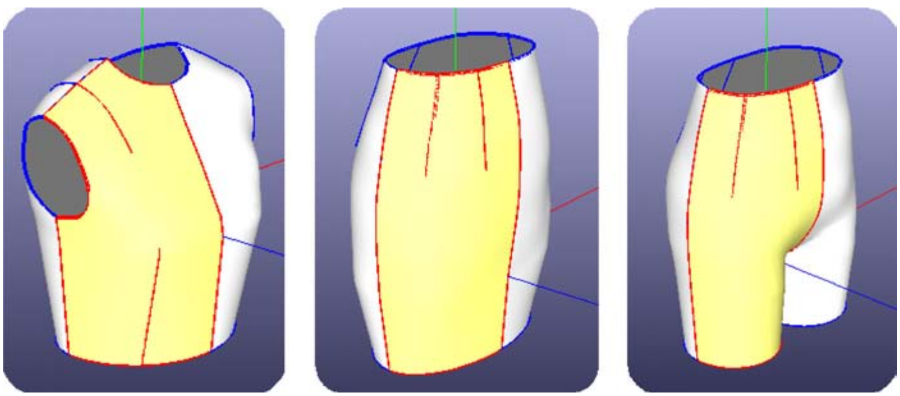


Figure 7. Examples of dart definition

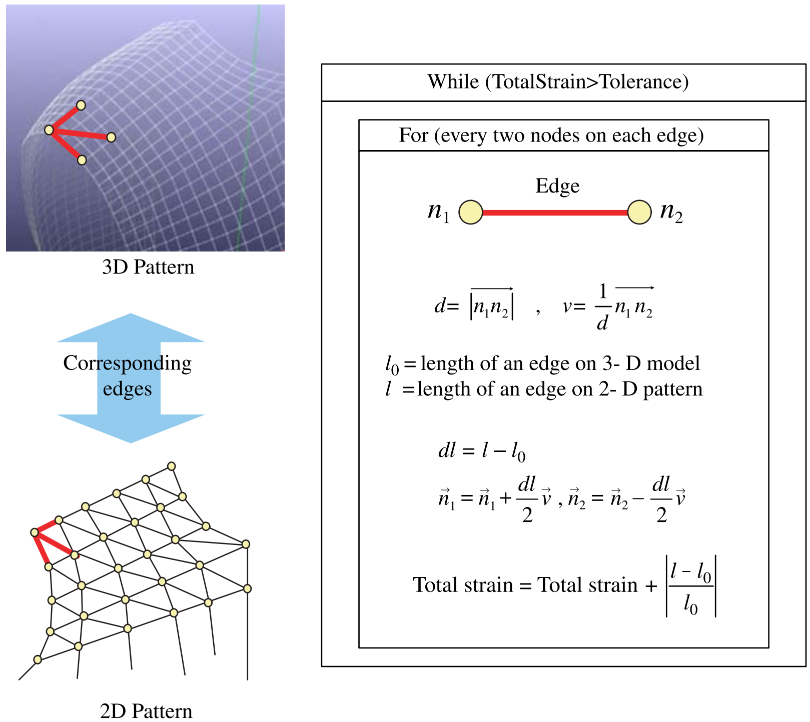


Figure 8.
Schematic diagram of strain reduction

2D and 3D pattern iteratively, residual strain in the projected pattern can be reduced. By this strain reduction method, resulting flat patterns can be obtained.

By considering the physical properties of the fabric material such as maximum elastic allowance and maximum shear angle allowance during the strain reduction, even the optimum shapes of patterns for different fabric material can assumed to be obtained. Some examples of flat patterns are shown in Figure 9. Strain reduction is terminated after the rate of change in total strain reached a predefined threshold value. The distribution of residual strain is visualized on the flattened patterns to guide the users for the better placement of darts.

However, as the number and positions of darts are determined entirely by the user and therefore the physically optimum number and positions of darts cannot always be obtained by this method. Of course, there are certain algorithms to determine the optimum cutting lines for the flattening of undevelopable surfaces (McCartney *et al.*, 1999, 2000, Wang *et al.*, 2004). But the applicable range of those methods are usually limited and the cutting lines suggested by those methods usually have the arbitrarily curved shapes and it is not desirable to introduce such complicated cutting lines to garment patterns because of the limitations not only in the design but also in the producibility of the garment. In this study, an automatic dart generation algorithm was developed to make approximately linear darts along the mesh structure as described in the manual dart definition method. Assuming the rectangular topology of a pattern, darts can be initiated from one of its four edges and can be drawn inward perpendicular to each edge as shown in Figure 10. The principle of this automatic dart

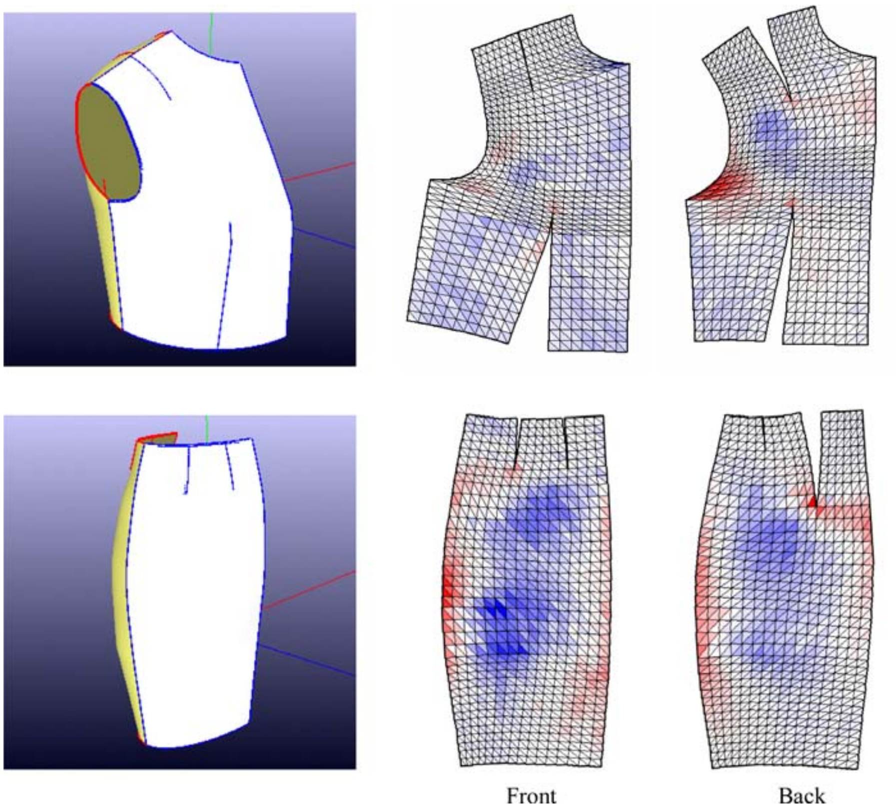


Figure 9.
Examples of flattened patterns with user-defined darts

generation method is described in detail in our previous research (Kim and Kang, 2002).

The suitability of the automatically generated darts can be verified by the visualized result of residual strain distribution.

Results and discussion

As shown in the above examples, garments with various sizes and silhouettes could be designed prior to the actual prototyping process. Therefore, the method developed in this study can be used to reduce the waste of both time and cost in conventional trial-and-error based processes. Once designed, garments are managed by a database system as the templates that users can design a new garment from on a similar one stored in the database to save their time.

Conclusion

In this study, a basic pattern generation system has been developed which generates flat garment patterns by modeling and flattening the 3D garment models. For this, a garment is divided into two zones including the fit zone and the fashion zone. The fit zone was modeled by digitizing the body scan data so that its size and shape could be modified in a parametric way. The fashion zone was modeled by parameterizing the

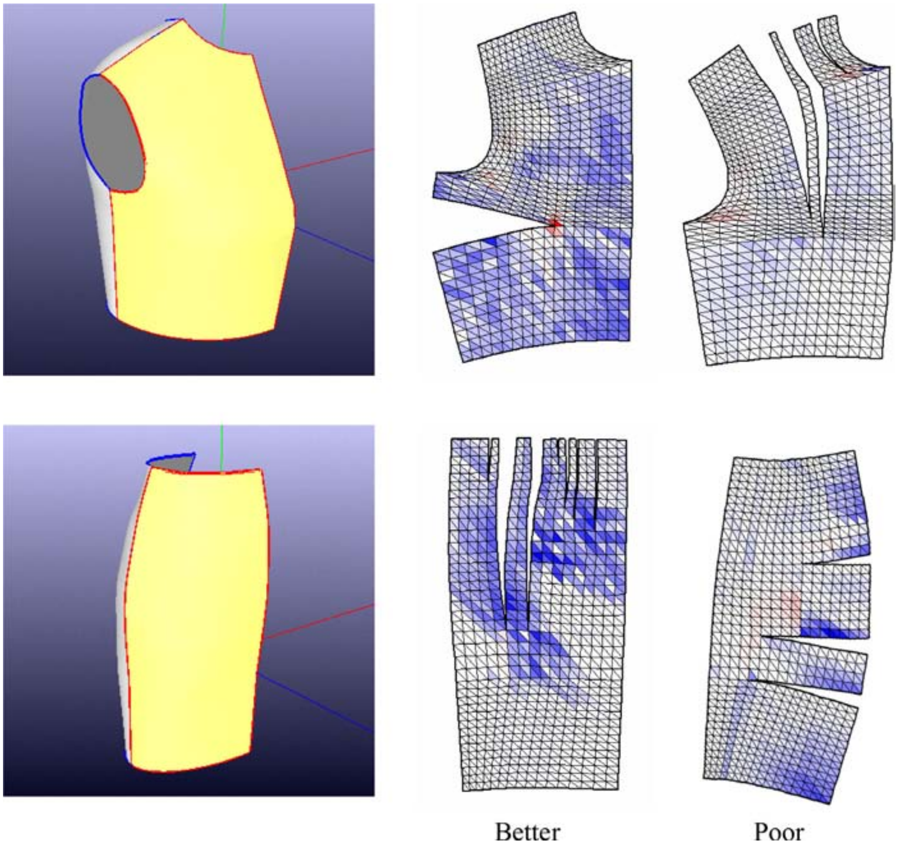


Figure 10.
Example of automatic dart formation

aesthetic appearance of garment silhouette so that the users can design various garment intuitively. Also a database management system for garment shape templates has been developed so that the users can design various garments ranging from basic items to fancy ones rapidly. Finally, a flat pattern projection algorithm has been developed to make flat patterns considering the physical properties as well as producibility of garment. Automatic pattern generation system will be a necessary tool to meet the future trend in manufacturing industries such as the mass-customization and the quick-response system.

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