CAD System for Japanese Kimono

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Abstract— **A yukata is the same shape regardless of wearer's heights or weights. An arrangement of its texture pattern becomes an important factor for designing the yukata. It is desirable to draw the cutting pattern so that the yukata should set the wearer up. Because drawing the cutting pattern requires great skill, it causes difficulties for beginners to draw the cutting patterns. In this paper, we propose the CAD system that support designers for drawing cutting patterns.**

1) By using this CAD system, the beginners can draw the cutting pattern of the yukata which is in harmony with the wearer's personality.

2) By the texture analysis of the striped pattern and the stencil pattern, the cutting pattern is drawn semi-automatically.

I. INTRODUCTION

The kimono is Japanese traditional clothing. And a yukata is a kind of cotton kimono. Recently, it has become popular for young people to wear yukatas during the celebration of summer festivals. Because the shape of the yukata is a simple, the arrangement of its texture pattern allocation becomes an important factor for designing the yukata. However designers have difficulty in drawing cutting patterns with arrangement. In this paper, we are proposing a CAD system that supports designers who have difficulty in drawing cutting patterns. The cutting pattern is obtained automatically by using this CAD system. By the texture analysis of the striped pattern and the stencil pattern, the yukata with these texture pattern can be designed semiautomatically.

II. THE BASIC OF KIMONO

A. Kimono structure

Fig. 1 shows a basic kimono pattern. The kimono consists of body sections, sleeves, overlaps and a collar. All kimonos are the same shape and are of a standard size that can be worn by anyone [1]. Fig. 2 shows a cutting pattern of the kimono. The kimono cloth is 36 cm in width and 1200 cm in length. The kimono cloth is cut at cutting lines as shown in Fig. 2. The texture pattern of the kimono repeats each 100 cm. The sizes of the parts are estimated from wearer's stature, hip measurement and sleeve length.

Fig. 3 shows the cutting pattern of the body sections. Total length is estimated as follows.

$$Totallength = (Stature + 5\text{cm}) + Margin(2\text{cm}) \quad (1)$$

A body section requires a piece of kimono cloth as twice as total length. Body width is estimated as follows.

$$BodyWidth = (\frac{1}{2} \times Hip + 7\text{cm}) + (2\text{cm}) \quad (2)$$

Sizes of other parts are also estimated from wearer's measurements. One piece of kimono cloth for body sections and sleeves are folded as shown in Fig. 1 [2].

B. Alignment of the yukata

The some variety of the yukata is made from the same kimono cloth by designing its cutting pattern. Fig. 4 shows the cutting pattern after alignment. The cutting pattern of Fig. 2 has no scrap, but the cutting pattern of Fig. 4 has some scraps. Required kimono cloth sometimes exceeds 1200cm in responsible with wearer's

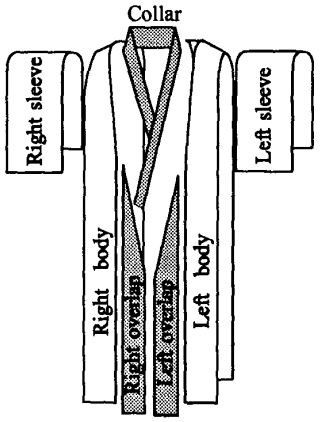


Fig. 1. The basic kimono

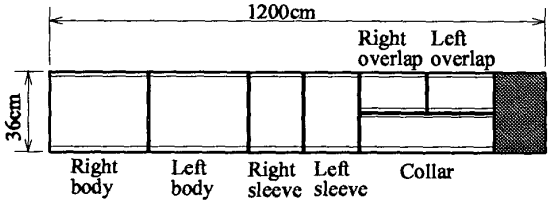


Fig. 2. The cutting pattern

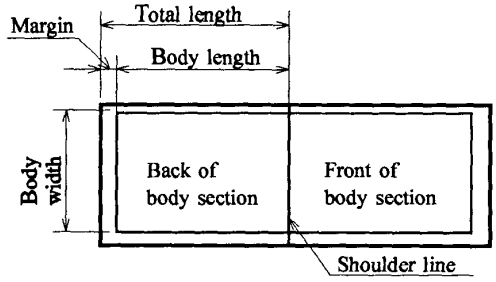


Fig. 3. The size of body sections

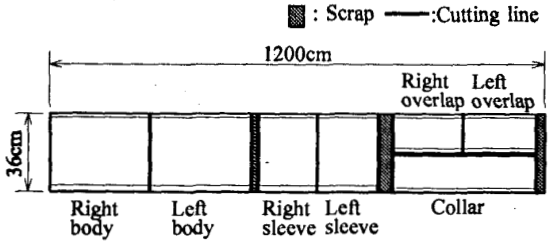


Fig. 4. The cutting pattern with alignment

stature, sleeve length and hip measurement or the kimono design. It makes the design difficult. There are some rules for designing a kimono with some kind of textile pattern. A striped yukata is designed so that the stripes of each parts becomes match up with each other. A yukata with the stencil patterns are designed in order to balance their stencil patterns allocation.

III. CAD SYSTEM FOR JAPANESE KIMONO

A. Basic structure of this CAD system

The right body section, the left body section, the right sleeve, the left sleeve and the left overlap are designed by the order as shown in Fig. 5. The CAD system consists of two screens and a menu. Fig. 6 shows the screen which shows the designed yukata. The yukata is shown immediately as the cutting pattern for the yukata has been changed. Fig. 7 shows the cutting pattern. In this screen, the cutting positions of the left and right body sections, the left and right body sections and the left overlap are pointed by the mouse pointer. The kimono cloth is digitized into 72 pixels by 200 pixels. The wide variety of design can be done by using the texture pattern upside down. The texture can be upside down by selecting "Direction" from the menu. The cutting pattern for the yukata is printed out by selecting "Print" from the menu.

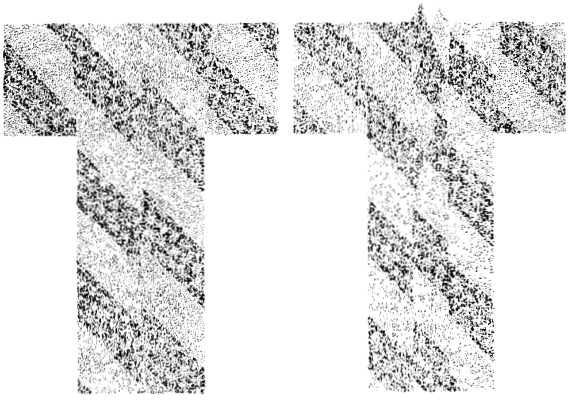


Fig. 6. The designed yukata on the screen

B. Automatic alignment of the striped yukata

The striped yukata is designed so that the stripes of the parts are match up with each other on the joints. This CAD system aligns the stripes of the left body section, the right sleeve, the left sleeve and the left overlap automatically to be match up with the right body section. The left body section is aligned to the right body section as follows.

The stripe pattern of the back side is digitized into a gray level image. The points which are on the edge of the stripe are detected from the image by median filter, Laplacian filter and thresholding. By the least square method, the edge of stripes are detected as some parallel lines as shown in Fig. 8[5]. We choose a line which is closest to the back hem. A point $\mathbf{P}_r$ is detected as a cross point between the detected line and back center seam. Fig. 9 shows a yukata and its cutting pattern before their patterns are matched. If the left body section matches with the right body section, $\mathbf{P}_l$ will align itself to $\mathbf{P}_r$. The gap with the left and the right body sections is estimated from the distance between the points. It is estimated as dx. Fig. 10 shows the design after the pattern has been matched. Its cutting pattern is as shown here. The left body section is cut from the end of the right body in dx. In the same way, the right sleeve, the

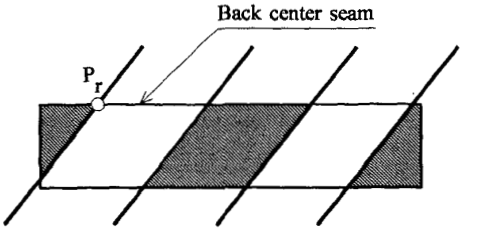
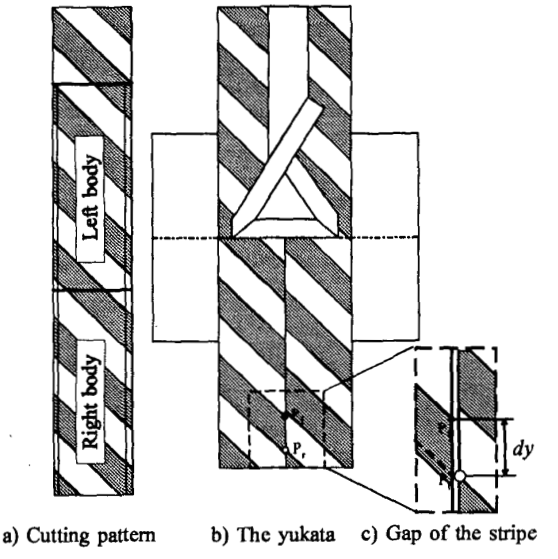
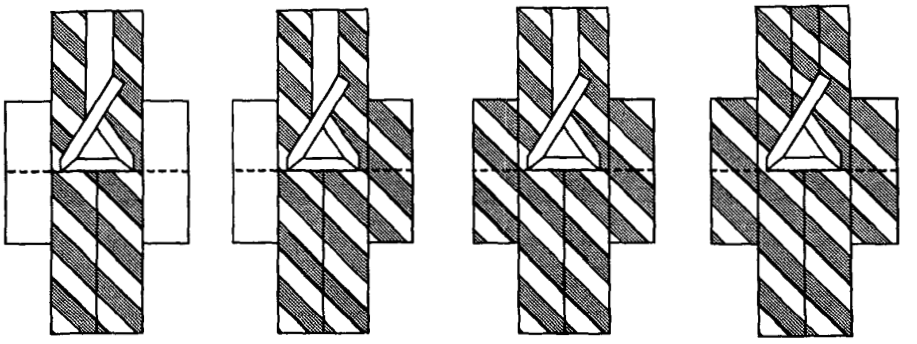


Fig. 8. The detected $\mathbf{P}_r$



a) Cutting pattern b) The yukata c) Gap of the stripe

Fig. 9. The left and right body sections before alignment



a) Left body b) Rigtht sleeve c) Left sleeve d) Left overlap

Fig. 5. Alignment of the yukata

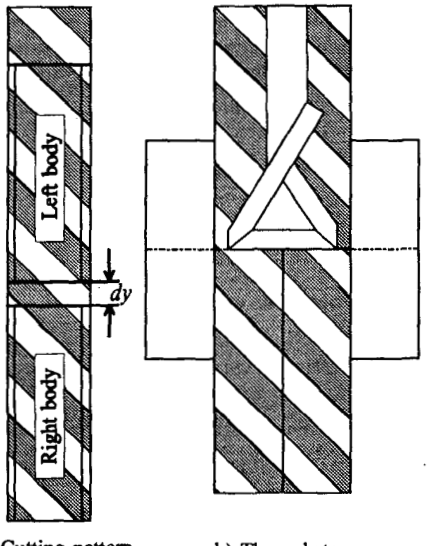
Fig. 7. Cutting pattern of the yukata

left sleeve and the left overlap are aligned to the right body section automatically [4].

C. Automatic alignment of the yukata with stencil patterns

The yukata having stencil patterns such as butterfly or flower patterns are designed in order to balance their patterns.

Fig. 11 a)shows the back of the right body section. The origin is the center of the back hem. Its x axis is set horizontally and y axis is set vertically. One hundred of small areas $r_1, r_2, \ldots, r_{100}$ are set from the back hem toward the shoulder at 1cm intervals. After thresholding, a binary image is obtained. The number of white pixels in the small regions are counted. However, if the pixel is in the area of $x \geq 0$, the count increases by 1 and if the pixel is in the area of $x < 0$, the count decreases by 1. The results of counting the pixels $a_1, a_2, \ldots, a_{100}$ are derived for each small regions respectively. In the same way, $b_1, b_2, \ldots, b_{100}$ are derived from the left body section. The numbers of the white pixels are shown as the curves $f_r(y)$ and $f_l(y)$ as shown in Fig. 12. A correlation R between $a_1, a_2, \ldots, a_{100}$ and $b_1, b_2, \ldots, b_{100}$ are estimated as follows.



a) Cutting pattern b) The yukata

Fig. 10. The left and right body sections after alignment

$$R = \frac{S_{ab}}{\sqrt{S_{aa} \cdot S_{bb}}} \tag{3}$$

$$S_{ab} = \sum_{i=1}^{100} (a_i - \bar{a}) \cdot (b_i - \bar{b}) \tag{4}$$

$$S_{aa} = \sum_{i=1}^{100} (a_i - \bar{a})^2 \tag{5}$$

$$S_{bb} = \sum_{i=1}^{100} (b_i - \bar{b})^2 \tag{6}$$

The variable $\bar{a}$ is an average of $a_1, a_2, \ldots, a_{100}$ and the variable $\bar{b}$ is an average of $b_1, b_2, \ldots, b_{100}$. Fig. 13 a) shows a yukata of undesirable design with stencil patterns. The yukata is monotonous because the stencil patterns of the left body section is exactly same as the stencil patterns of the right body section. In this case, the correlation R is almost 1. Fig. 13 b) shows the other yukata of undesirable design. The yukata is not preferable because the stencil patterns are imbalance.

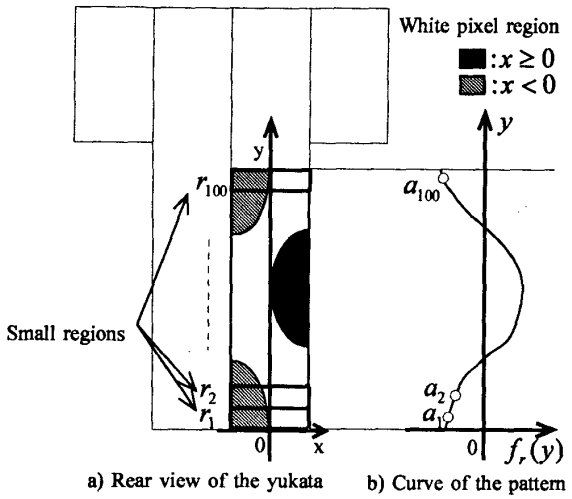


Fig. 11. Pattern of the right body section

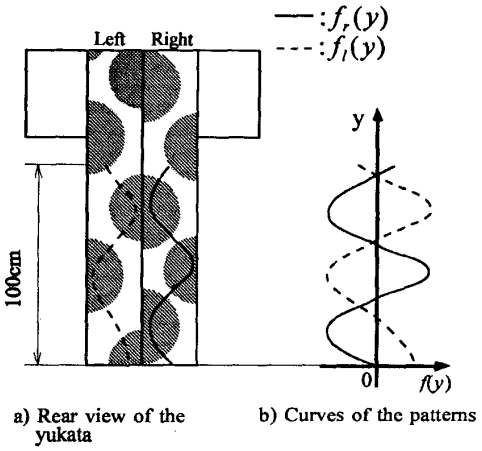


Fig. 12. Comparison of the pattern between the left and the right body sections

In this case, the correlation R is almost -1. Since it is preferable to design the left body section so that the correlation R should be 0. The correlation are changed as the left body section moves to the shoulder. Then the left body section is designed so that the correlation should be closest to 0.

In the same way, the right sleeve, the left sleeve and the left overlap are designed automatically.

D. Reducing the scrap of the kimono cloth

As a result of the alignment, an amount of scrap of the kimono cloth increases.

Fig. 14 a) shows the cutting pattern of the left body and the right sleeve after alignment. The first end of the right body is cut at a_1 and the last end is cut at b_1. The right sleeve is cut at a_2 and b_2. The cutting position a_1, b_1, a_2 and b_2 are derive as the lengths between the end of the kimono cloth and the cutting positions. The length of required kimono cloth is L_1. The unit of the texture pattern is shown by dashed line.

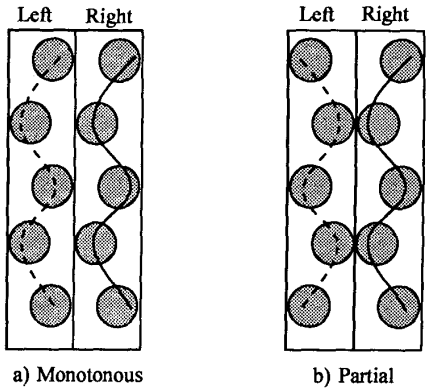


Fig. 13. Undesirable designs

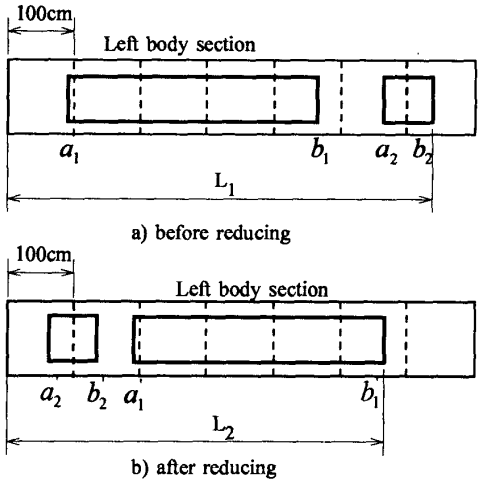


Fig. 14. Reducing the scrap of the kimono cloth

The order of the parts is changeable. Fig. 14 b) shows the cutting pattern after changing the order. The yukata derived from Fig. 14 b) is as same as the yukata derived from Fig. 14 a). In this cutting pattern, the length of required kimono cloth L_2 is shorter than the length L_1. There are 120 patterns of parts orders for the cutting pattern. The cutting pattern is chosen for the reason that it requires the least kimono cloth.

IV. EXPERIMENTAL RESULTS

We designed a striped yukata, a chevron striped yukata and a yukata with butterfly patterns for the wearer whose stature is 155cm, sleeve length is 61cm and hip measurement is 82cm.

A. The striped yukata

Fig. 15 shows the designed striped yukata. Their stripes are matched up with each other. Fig. 16 shows the its cutting pattern.

Fig. 17 shows the chevron striped yukata which is a variety of the striped yukata. It is more impressive

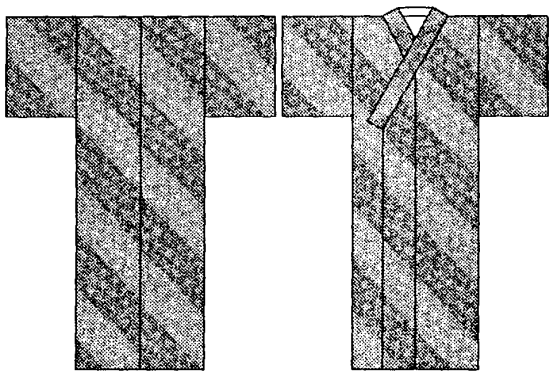


Fig. 15. The striped yukata

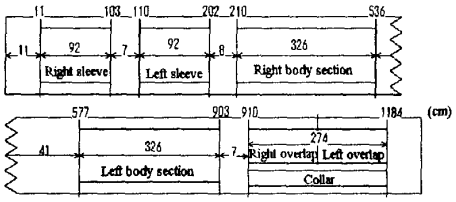


Fig. 16. The cutting pattern of the striped yukata

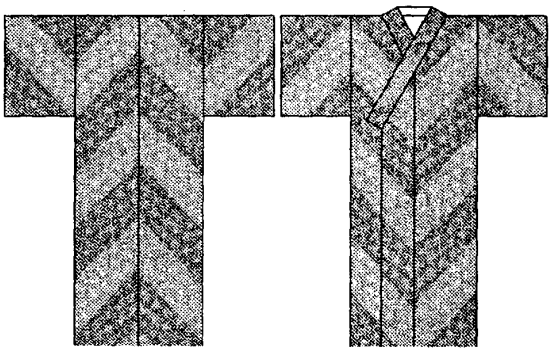


Fig. 17. The chevron striped yukata

than the striped yukata. The stripes of the left body section and the right sleeve are upside down. Its stripes are matched up each other as same as the striped yukata. Fig. 18 shows the its cutting pattern. In this case, the required kimono cloth exceeds 1200cm.

B. The yukata with butterfly patterns

Fig. 19 shows the yukata with butterfly patterns. It is designed with a correlation $R = 6.9 \times 10^{-5}$. Fig. 20 shows its cutting pattern.

V. CONCLUSIONS

We developed a CAD system for the yukata.

1) By using this CAD system, the beginners can arrange the yukata and obtain its cutting pattern.

2) By the texture analysis of the striped pattern and the stencil pattern, the cutting pattern is drawn semi-automatically.

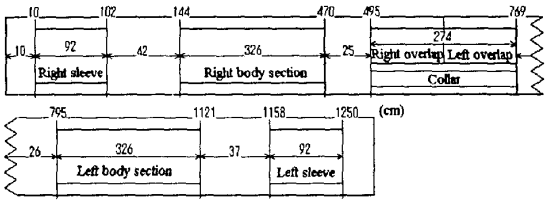


Fig. 18. The cutting pattern of the chevron striped yukata

Fig. 19. The yukata with butterfly patterns

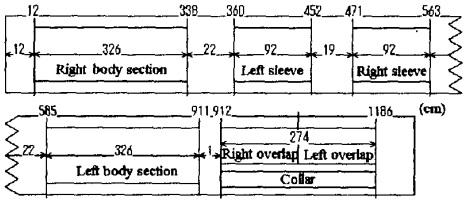


Fig. 20. The cutting pattern of the yukata with butterfly patterns

This CAD system can be applicable to the yukata design.

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