Intelligent Design Support System for Japanese Kimono

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Abstract— **A yukata is a type of traditional Japanese clothing. The designers have difficulty in drawing its cutting pattern with texture alignment. In this paper, we describe about a CAD system for the yukata. First, we developed image processing algorithms for achieving the texture alignment. Second, we developed a measurement system for the wearer's body shape. Third, a three-dimensional garment simulation was achieved. By using this system, designers tailor easily the yukata regardless of their skill.**

I. Introduction

A yukata is a type of traditional Japanese clothing. There are a wide variety of texture patterns for the yukata. An alignment of its texture pattern becomes an important factor for the design of the yukata, because the yukata is the same shape regardless of the wearer's height or weight. However, designers have difficulty in drawing its cutting pattern with texture alignment. In this paper, we developed a CAD system that performs the texture alignment automatically. Stripe and stencil pattern are popular types of patterns. In order to perform the texture alignment, we detect the imbalance of the texture.

We developed image processing algorithms for the texture alignment of the striped yukata and the yukata with stencil patterns respectively.

For achieving a garment simulation, we developed a measurement system for wearer's body shape.

II. Methods

A. Basic of the kimono

Fig. 1 shows the basic kimono pattern. The kimono consists of a right body, a left body, a right sleeve, a left sleeve, a right overlap, a left overlap, and a collar. The most important data of the kimono are wearer's body shape, such as height, sleeve plus shoulder and hip. The size of the yukata various kimono parts such as left body, left sleeve and so on is determined by these data. A yukata is the same shape. Fig. 2 shows cutting patterns of yukata. A yukata is made of a kimono cloth. The kimono cloth is 1200cm in length and 36cm in width. Before the texture alignment, there are no scraps between the parts. After the texture alignment is performed, there are some scraps between the kimono parts[1]. The cutting pattern is automatically estimated by this CAD system.

B. CAD system

Fig. 3 shows the display of the CAD system. A front view, a rear view of the yukata and a texture pattern of the kimono cloth are shown. We design the body sections, the sleeves and the left overlap. The size of

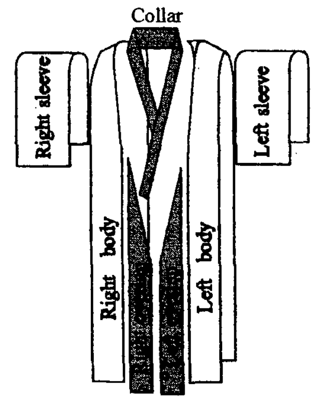

Fig. 1. Basic kimono pattern.

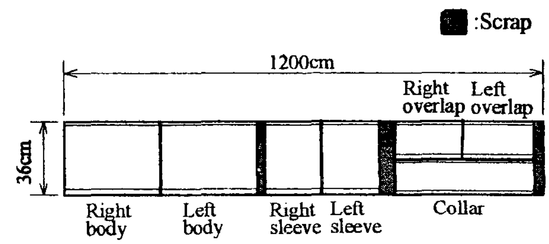

Fig. 2. Cutting pattern of yukata.

the yukata is calculated automatically from the wearer's body data[2].

This system performs automatic texture alignment with a striped yukata or with a yukata with stencil patterns. Fig. 4 shows the alignment order. As a first step of alignment, the designer decides the yukata texture of the right body section. The left body section and the right sleeve are aligned to the right body section. The left sleeve and the left overlap are aligned to the left body section.

The striped yukata is designed so that its stripe matches up with each other. The texture pattern of the kimono cloth is inputted by a CCD camera. The image has 256. The stripes are detected as parallel lines by image processing such as median filtering, thresholding, and labelling as shown in Fig. 5. We set a mark Pr on the right body section. Fig. 6 shows the relation between the gap of the stripes and estimated scraps. The $\mathbf{P}_l$ is detected on the left body section. If the left

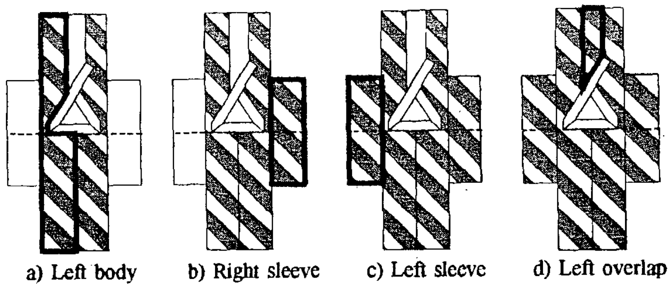

Fig. 4. Alignment order of the yukata texture.

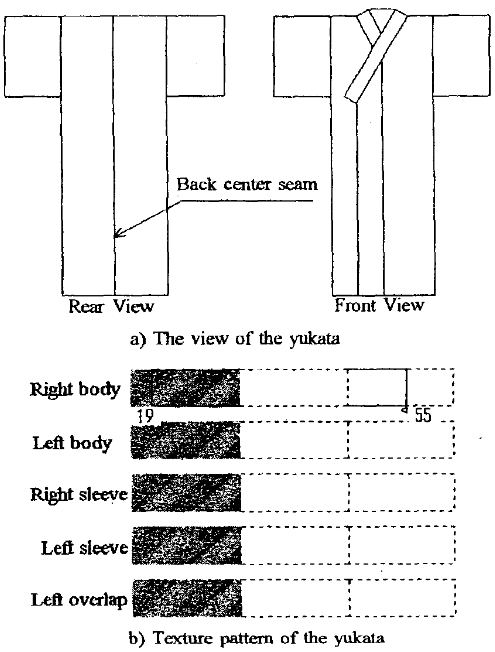

Fig. 3. CAD system.

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 $\mathbf{P}_l$ and $\mathbf{P}_r$. The length of the scrap dy is estimated.

The texture alignment with stencil patterns is as follows.

Fig. 7 shows the yukata with the stencil patterns. The pixels of the stencil pattern are detected by the image processing. The function $f_r(y)$ is the projection of the pixels in the right body section on the y axis. The value of $f_r(y_i)$ is the count of the pixels in the left side of the right body section minus the count of the pixels in the left side. In order to align the left body section to the right body section, the function $f_l(y)$ from the

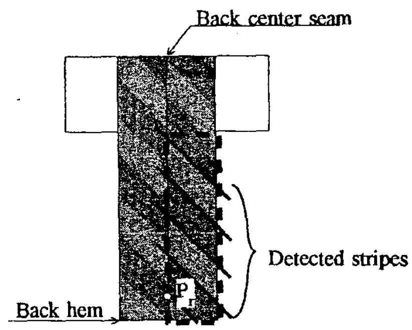

Fig. 5. Detection of the stripe pattern.

left body section is estimated in the same way. A correlation between $f_r(y)$ and $f_l(y)$ is estimated to evaluate the balance of the stencil patterns. A correlation R is defined as follows.

$$R = \frac{S_{lr}}{\sqrt{S_{rr} \times S_{ll}}} \tag{1}$$

$$S_{lr} = \sum_{i=1}^{100} (f_r(y_i) - \bar{f}_r) \bullet (f_l(y_i) - \bar{f}_l) \tag{2}$$

$$S_{rr} = \sum_{i=1}^{100} (f_r(y_i) - \bar{f}_r)^2 \tag{3}$$

$$S_{ll} = \sum_{i=1}^{100} (f_l(y_i) - \bar{f}_l)^2 \tag{4}$$

$$\bar{f}_r = \frac{1}{100} \sum_{i=1}^{100} f_r(y_i) \tag{5}$$

$$\bar{f}_l = \frac{1}{100} \sum_{i=1}^{100} f_l(y_i) \tag{6}$$

Fig. 8 shows undesirable designs. We often feels monotonous with the design as shown in Fig. 8 a). In this design, the R is nearly equal to 1. The design as shown in Fig. 8 b) is felt partial. The R is nearly equal to -1. The texture alignment is performed for making the R become to 0.

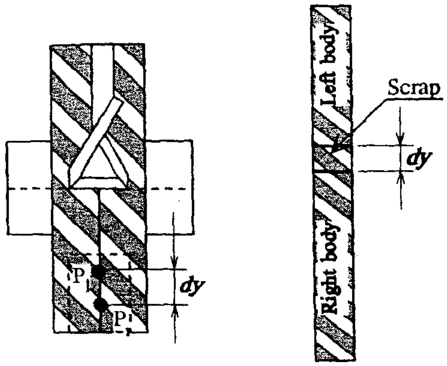

Fig. 6. Alignment of the stripes.

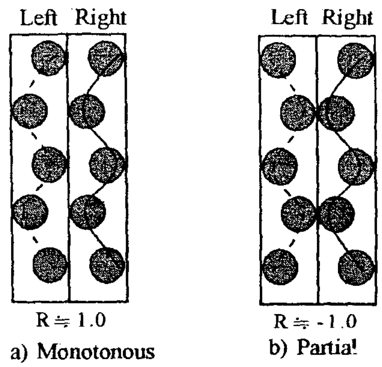

Fig. 8. Undesirable designs.

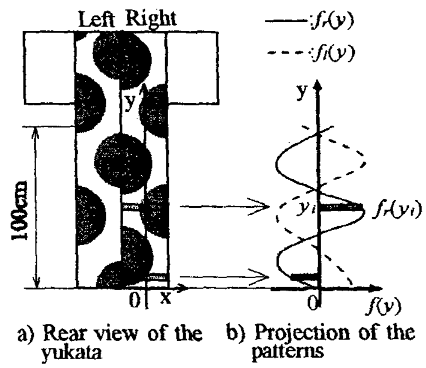

Fig. 7. Comparison of the stencil patterns.

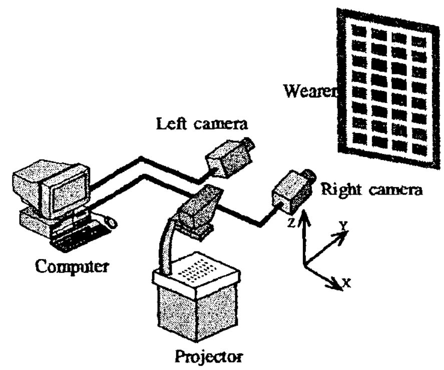

Fig. 9. Measurement system.

C. Measurement system for wearer's body shape

In order to achieve garment simulation, a measurement system for wearer's body shape is developed as shown in Fig. 9. The system consists of an overhead projector, two CCD cameras, and a personal computer. The wearer stands in front of the wall. The color patterns shown in Fig. 10 are projected to the wearer. The color patterns consist of green small regions which are arranged 20 in row and 15 in column. The color of the background is red. The color patterns are detected by an image processing algorithm as follows.

- Noise reduction
- Extraction of the color patterns
- Labelling of the color patterns

RGB to YUV conversion is carried out to the image data. Y component represents the luminance. U component and V component provide color information. The image processing is carried out in V component. First, the noise reduction is performed with the median filter. Second, the pixels of color patterns are extracted by adaptive thresholding. The small regions are set around the each pixel. The threshold value is an average of intensities in the small area. The color patterns are detected by their feature parameters of size and normalized area. The normalized area is the square of the contour length over the size. The regions that are near to the average in feature parameter are detected. Finally, the detected color patterns are numbered from the lower left to the upper right.

The distances between each color patterns and the camera are estimated by the stereovision method. The (X, Y, Z) coordinate system is used. The Y axis is perpendicular to the wall. The X axis and the Z axis are parallel to the wall. Fig. 11 shows the XY plane of the measurement system. The x_l and x_r represent the points which are the position of the color pattern $\mathbf{P}$ to be projected to the left and right CCD. The distance y_p is estimated by the stereovision method as follows.

$$y_p = \frac{f \times d}{x_l - x_r} \tag{7}$$

where the f is the focal distance of the cameras and the d is the distance between the left and the right cameras. The f and d the are estimated from the actual measurement. The distances between the camera and each center of the color patterns are estimated.

The wearer's body shape is derived as a matrix data of the distances between the color patterns and the camera.

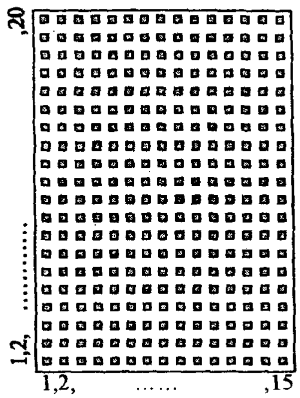

Fig. 10. Color pattern.

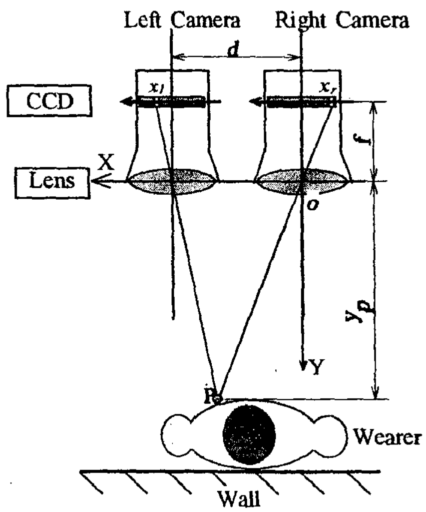

Fig. 11. Principle of stereovision method.

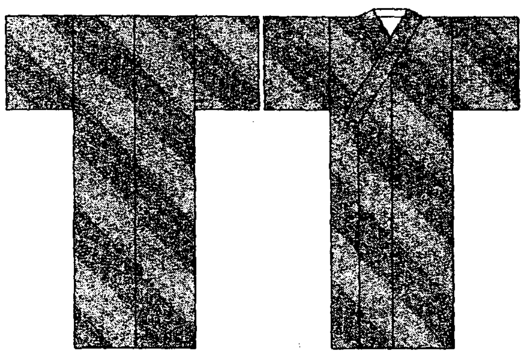

Fig. 12. Striped yukata.

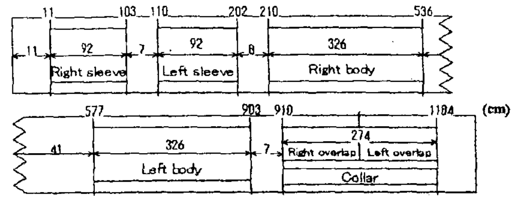

Fig. 13. Cutting pattern of the striped yukata.

Fig. 14. Yukata with butterfly patterns.

III. RESULTS

A wearer's height is 150cm, and the sleeve plus shoulder length is 59cm, and the hip is 79cm. Fig. 12 shows the striped yukata. The left body section, the sleeves and the left overlap are designed automatically so that its stripes match up with each other. Its cutting pattern is derived as shown in Fig. 13. Fig. 14 shows the yukata with stencil patterns. The yukata with stencil pattern is designed automatically so that its stencil patterns are with well-balanced location. Fig. 15 shows the cutting pattern derived by using this CAD system.

Fig. 16 a) shows the mannequin having the same as the wearer. By the image processing, the color patterns are derived as shown in Fig. 16 b). The shape of the mannequin is derived as the depth map as shown in Fig. 17. The garment simulations of the designed yukata shown in Fig. 12 and Fig. 14 are performed. Fig. 18 and Fig. 19 show the results of the garment simulation.

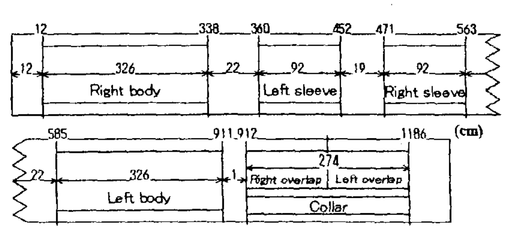

Fig. 15. Cutting pattern of the yukata with butterfly patterns.

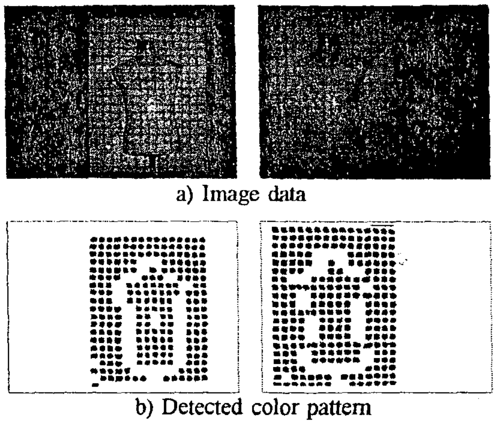

Fig. 16. Result of image processing.

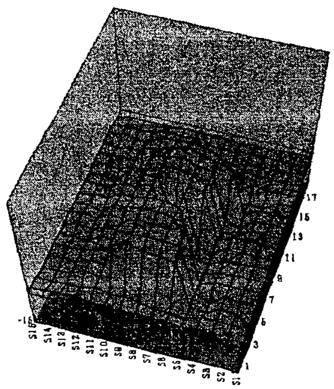

Fig. 17. Measurements of the body shape.

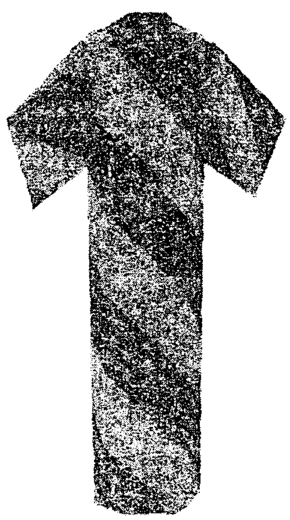

Fig. 18. Garment simulation of the striped yukata.

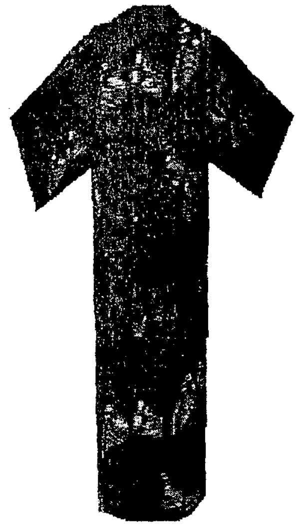

Fig. 19. Garment simulation of the yukata with butterfly patterns.

IV. CONCLUSIONS

We developed a CAD system for the yukata. Achievements are as follows.

(1) The cutting patterns for the yukata is automatically estimated.
(2) Texture alignment is automatically achieved.
(3) A garment simulation is performed with a simple measurement system.

As a result, designers tailor easily the yukata regardless of their skill by using this CAD system.

REFERENCES

[1] John Marshall, *Make Your Own Japanese Clothes,* Kodansha, 1988.
[2] Tetsuya Sano et. al., "Design Support System for Japanese Kimono," *IECON'98 Proceedings of the 24th Annual Conference of the IEEE Industrial Electronics Society,* Vol. 1, 1998, pp. 199-104.