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Study on Pattern Design Method of Women Tight Skirts Based on 3D Point-cloud Data

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Abstract

In this research, 100 female students aged from 18 to 24 years old were selected to take part in the body measurement. Data acquisition software named Imageware with a 3D scanner was employed to gain the body point-cloud diagram. Then, the characteristics of the young female lower body torso have been analyzed according to the data obtained. The regression of the key parts of women skirts and the characteristics of young female lower body torso has been found. Finally, the generating rules of the basic pattern of women skirts were established, which provides the foundation for auto-generation of skirt pattern.

Keywords: 3D Body Measurement; Women Skirts; Pattern Auto-generation; Imageware

1 Introduction

With the development of the times, people tend to require the individuation and fit of the clothing. Dress style, material, color, accessories and so on now needs to reflect the individual characteristics. Automatic generation of garment pattern development system can make the apparel industry more automatic and efficient to meet consumers' demands for more personalized and diverse clothing [1]. At present, the garment industry has achieved the automatic nesting and automatic cutting, but the automatic garment pattern generation system has not been born yet, as it is still at the exploratory stage. Some of these systems only have databases of various clothing styles for the standard model, which can neither automatically handle new clothing styles, nor be linked with the human body. And those linked with the body's systems still rely on the pattern makers' experience to modify and adjust the computer-generated model when dealing with the special body pattern [2].

Three-dimensional body measurements are accurate, at a high-speed and consistent, which can accurately reproduce the human body shape and its curve features [3]. Besides, it is simple

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in operation and can measure a number of projects. These measurement results can also be directly sent to the pattern design and automatic cutting system through the computer, to achieve continuous automatic discharge of body measurements, pattern design and cutting. And the development of non-contact 3D body measurement provides strong support for rapid access to three-dimensional shape parameter and human body model [4, 5, 6, 7].

This study uses three-dimensional measuring instrument to research the female characteristics of the lower body torso, then explores the generating rules of the basic pattern model of women skirts and provides the basis for the auto-generation of skirt pattern.

2 Anthropometry

2.1 Subjects, Time and Apparatus

80 female students aged from 18-24 years old of Soochow University were selected as research subjects for this study. The experiment was carried out during the period of 2010.9 $\sim$ 2010.12, by using the non-contact 3D body scanner Symcad of Telmat.

2.2 Measuring Items

The study uses the software of imageware as a tool to read and optimize the point-cloud data generated by the 3D body scanner, and separately obtains the heights, widths and thicknesses of the waist, abdomen, buttock and other data (Fig. 1) and whilst also manually measures the girths of waist, abdomen and buttock.

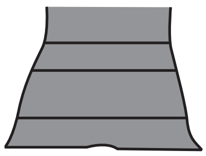


Fig. 1: 3D point-cloud schematic diagram

3 Data Analyzing

In the structural design of skirt, the main height sizes are the waist height, abdominen height and hip height. The main girth sizes are waist girth, abdomen girth and hip girth.

3.1 Data Obtainment of Height

3.1.1 Correlation of Height and Altitude

The altitudes of main body parts and height are closely related, and in order to determine how the altitudes of main body parts vary with the height and the selected proper model, it is necessary to analyze the correlations of them. Table 1 reflects the correlations of the altitudes of main body parts and height.

Table 1 shows that: the correlation coefficients of waist height, abdomen height and hip height with height are respectively 0.818, 0.722, 0.784. Two-tailed levels of significance are all 0.000 <0.001, indicating that the correlations of the altitudes of main body parts and height are very significant. Therefore this research can use linear regression to analyze the correlations of the altitudes of body main parts and height.

3.1.2 Altitude Fitting

Correlation analysis shows that the altitudes of main body parts and height all exhibit linear relationships. The following is the linear regression process, as shown in Table 2.

Table 1: Correlations of the altitudes of main body parts and height

	Pearson Correlation	Sig.(2-tailed)	N
Waist	0.818**	0.000	80
Abdomen	0.722**	0.000	80
Hip	0.784**	0.000	80

**. Correlation is significant at the 0.01 level (2-tailed).

Table 2: Coefficients

	Un-standardized coefficients		t	Sig.
	B	Std. Error		
Waist	−22.825	10.297	−2.217	0.030
	0.742	0.064	11.561	0.000
Abdomen	−29.95	13.909	−2.153	0.035
	0.736	0.087	8.488	0.000
Hip	−25.070	10.105	−2.481	0.016
	0.645	0.063	10.244	0.000

Table 2 shows that: In the regression of the waist height, abdomen height, hip height and height, the t-values which identify the significance of the regression constant in equation are −2.217, −2.153, −2.481 respectively, with a probability of 0.030, 0.035,

0.016 respectively; the t-values which identify the significance of coefficient are 11.561, 8.488, 10.244, and their probability are all $0.000<0.001$, so the regression coefficients are very significant. The regression equation can be integrated:

$$\mathrm{Y1} = -22.825 + 0.742 * \mathrm{X} \tag{1}$$

$$\mathrm{Y2} = -29.95 + 0.736 * \mathrm{X} \tag{2}$$

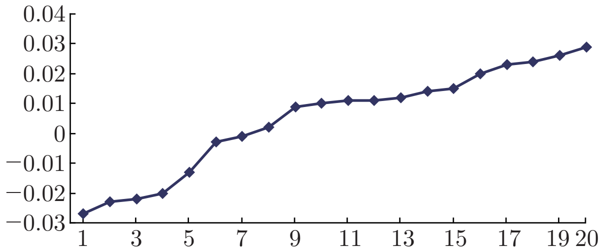
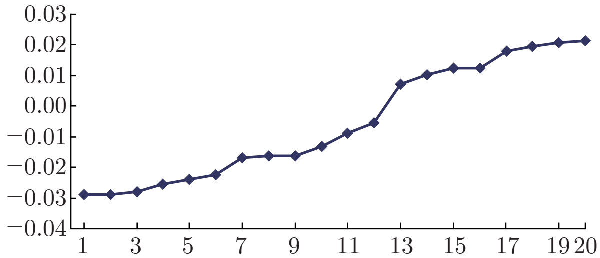
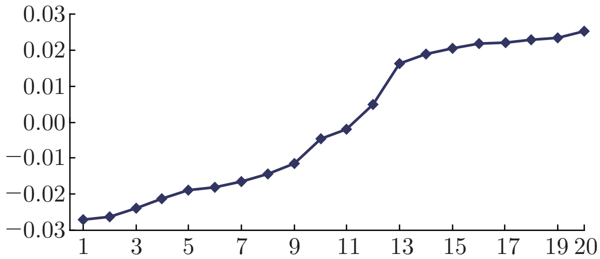
$$\mathrm{Y3} = -25.070 + 0.645 * \mathrm{X} \tag{3}$$

X states height, Y1 states waist height, Y2 states abdomen height, Y3 states hip height.

3.1.3 Data Validation of Height Data

Selecting 20 other samples as a validation measure, and then bringing the measurement data into (1)∼(3), the error analysis of measured and calculated values are shown in Table 3. Table 3 shows that the two errors are within ±3%, which meets the needs of apparel structure design.

Table 3: Error analysis

	Number of samples	Error distribution	Error upper limit	Error down limit
Waist	20		−0.027	0.029
Abdomen	20		−0.029	0.021
Hip	20		-0.027	0.025

3.2 Data Obtainment of Girth

3.2.1 Classification of Young Female Body Size

The features of the shape section of main body girth is mainly reflected in the different levels of flat, so this paper classifies the female body data according to the ratios of thickness and width of them. With the stall difference of 0.1, we classify the female body data separately through the ratios of waist thickness and waist width, abdomen thickness and abdomen width, hip thickness and hip width. Among them, the ratio of waist thickness and waist width takes the stalls of 0.6, 0.7, 0.8, 0.9 respectively, and the ratio of the abdomen thickness and abdomen width takes the stalls of 0.6, 0.7, 0.8 respectively , whilst the ratio of hip thickness and hip width takes the stalls of 0.6, 0.7 respectively.

3.2.2 Regression of Girth

The main difference of different sizes is reflected in the difference of the former waist girth and back waist girth, the former abdomen girth and back abdomen girth, the former hip girth and back hip girth. It is proven that the former waist girth and waist girth, former abdomen girth and abdomen girth, back hip girth and hip girth exhibit linear relationships and their regression equations are shown in Table 4.

Table 4: Regression equation of each related part

X	Y	Y= a + b*X							
		0.6		0.7		0.8		0.9	
		a	b	a	b	a	b	a	b
Waist	The former waist	−4.072	0.572	−3.144	0.566	1.654	0.504	−39.431	1.101
Abdomen	The former abdomen	−3.219	0.538	3.754	0.462	10.694	0.385		
Hip	The back hip	6.148	0.464	0.986	0.523				

3.2.3 Data Validation of Girth Data

Selecting 20 other samples as a validation measure, and then bringing the measurement data into Table 4, the error analysis of measured and calculated values are shown in Table 5, in which we can see the two errors are within ±2%, which meet the needs of apparel structure design.

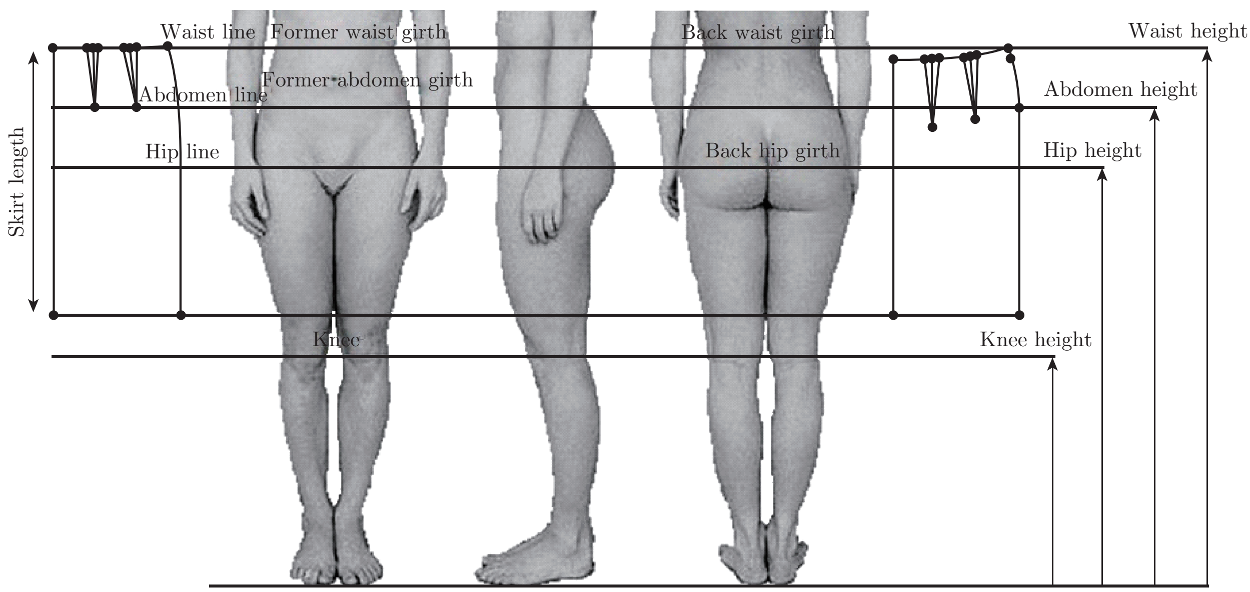


Fig. 2: Correspondence of main structure line of skirt with human body

Table 5: Error analysis

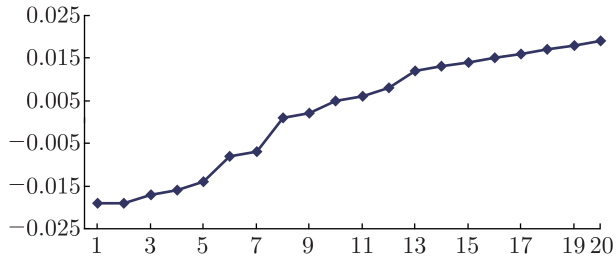
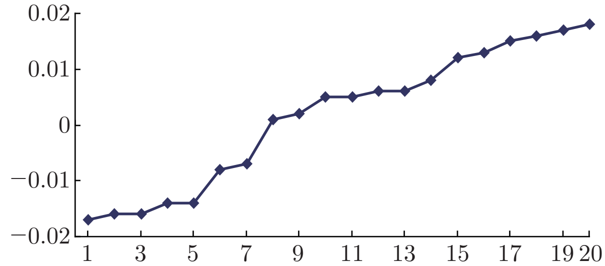
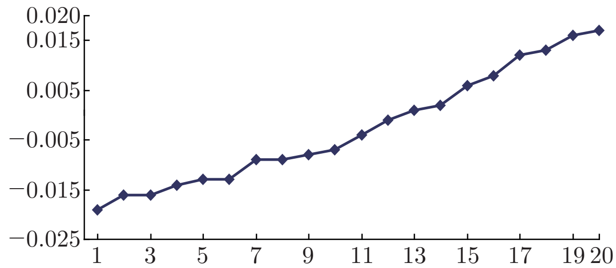
	Number of samples	Error distribution	Upper limit error	Down limit error
The former waist	20		−0.019	0.019
The former abdomen	20		−0.017	0.018
The back hip	20		−0.019	0.017

Table 6: Correspondence of structure line and anthropometric data

Skirt sheet structure line	anthropometric data
Waist line	Waist girththe former waist girthwaist height
Abdomen line	Abdomen girththe former abdomen girthabdomen height
Hip line	Hip girththe back hip girthhip height
Skirt's length	Knee height

4 Samples Generation

4.1 The Basic Position of the Correspondence Between Skirt Sheet Structure Line and Anthropometric Data

The main structural lines of skirt are waist line, abdomen line, hip line and the side seam. Their correspondences with anthropometric data are shown in Table 6 and Fig. 2.

4.2 The Generating Rules of Pattern Model of Tight Skirts

The paper selects female bodies with height of 160 cmand waist of 68 cm as an example to design dress pattern. Fitting body feature and related data are shown in Tables 7 and 8.

Table 7: Standard female body size (unit: cm)

height	Waist girth	Abdomen girth	Hip girth	Waist thickness/ width	Abdomen thickness/ width	Hip thickness/ width
160	68	72	92	0.6	0.6	0.6

Table 8: Fitting data (unit: cm)

The former waist girth	The former abdomen girth	The back hip girth	Waist height	Abdomen height	Hip height
34.82	70.34	46.08	95.89	87.81	78.13

When the skirt length is 60 cm, the waist line for X- axis, the former and back seam for Y-axis, separately establishes the coordinate systems, as shown in Fig. 3 and Fig. 4.

a. The generating rules of front skirt sheet

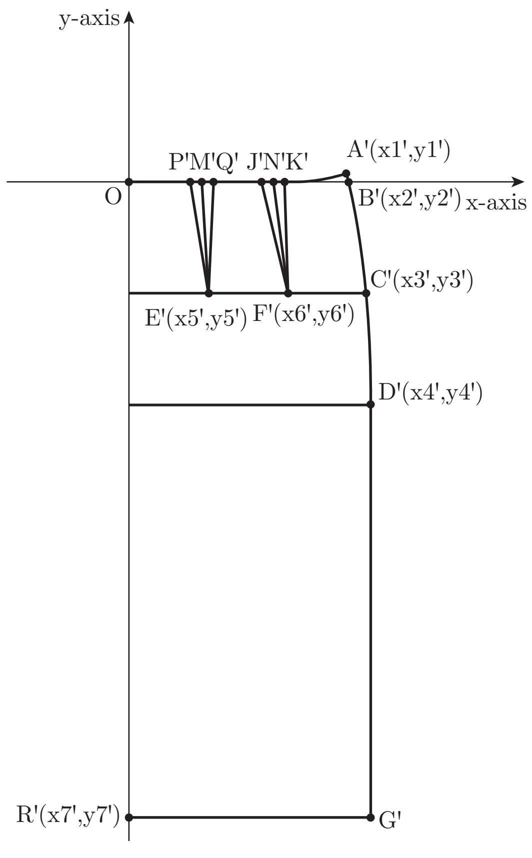


Fig. 3: Front skirt sheet

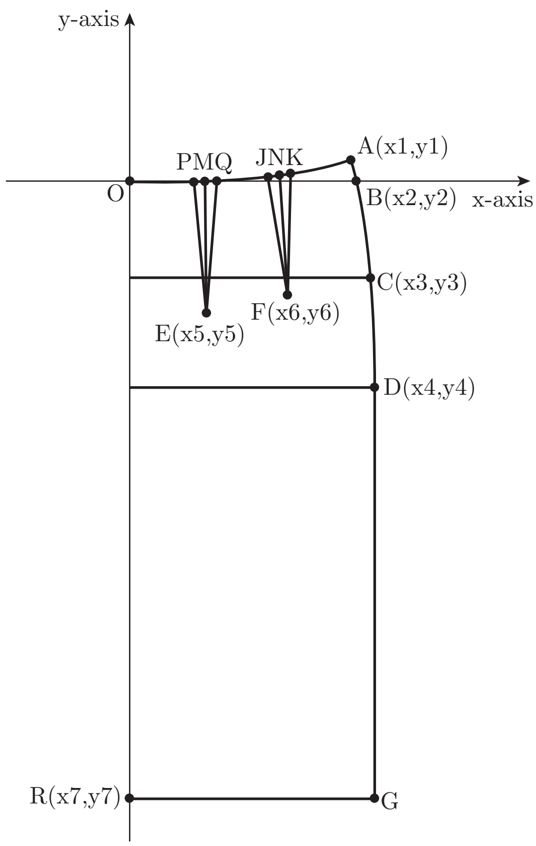


Fig. 4: Back skirt sheet

1 Determine the B' point coordinates, x2' = the former waist / 2 + provincial amount ∘ (∘ = (Hips - Waist) / 8), y2' = 0;

2 Determine the C' point coordinates, x3' = the former abdomen girth / 2 + loose volume, y3' = abdomen height - waist height;

3 Determine the D' point coordinates, x4' =(hip girth - the back hip) / 2 + loose volume, y4'= hip height - waist height;

4 Determine the A' point coordinates, x1' = x2'-0.5, y1' = 0.7;

5 Determine the R'point coordinates, x7'= 0, y7'= 60;

6 Connect A', B', C', D' points, making them in a smooth curve;

7 Make a horizontal line from point R', a vertical line from point D', Intersecting at point G';

8 Determine point E', F' coordinates, x5' = x3'/ 3, y5' = y3'-2, x6'= x3' * 2 / 3, y6' = y3'-1;

9 Connect arc O'A', making it smoothly;

10 Draw E'M' perpendicular to the arc O'A', intersecting arc O'A' at point M, draw F'N' perpendicular to the arc O'A', intersecting arc O'A' at point N';

11 In the arc O'A', taking M' as the midpoint, draw the arc as long as ∘/2, intersecting O'A' at point P'Q', then connect E'P'E'Q', similarly, draw F'J', F'K';

12 The surrounded graph by point O', P', M', Q', J', N', K', A', B', C', D', G', R' is half of the front tight skirt sheet.

b. The generating rules of back skirt sheet

1 Determine the B point coordinates, x2 = (waist - the former waist) / 2 + provincial amount ∘ (∘ = (Hips - Waist) / 8), y2 = 0;

2 Determine the C point coordinates, x3 = (abdomen girth - the former abdomen girth) / 2 + loose volume, y3 = abdomen height - waist height;

3 Determine the D point coordinates, x4 =the back hip / 2 + loose volume, y4 = hip height - waist height;

4 Determine the A point coordinates, x1 = x2-0.5, y1 = 0.7;

5 Determine the R point coordinates, x7 = 0, y7 = 60;

6 Connect A, B, C, D points, making them in a smooth curve;

7 Make a horizontal line from point R, a vertical line from point D, intersecting at point G;

8 Determine point E, F coordinates, x5 = x3 / 3, y5 = y3-2, x6 = x3 * 2 / 3, y6 = y3-1;

9 Connect arc OA, making it smoothly;

10 Draw EM perpendicular to the arc OA, intersecting arc OA at point M, draw FN perpendicular to the arc OA, intersecting arc OA at point N;

11 In the arc OA, taking M as the midpoint, draw the arc as long as ∘/2, intersecting OA at point P, Q, then connect EP, EQ, similarly, draw FJ, FK;

12 The surrounded graph by point O, P, M, Q, J, N, K, A, B, C, D, G, R is half of the back tight skirt sheet.

5 Conclusion

This study measured and analyzed point-cloud data obtained by the 3D body scanner, and then derived the correspondence between the necessary body feature data of skirt structure design and the key parts values of the fundamental skirt styles. Making tight skirt as an example, this study establishes the generating rules of tight skirt pattern, which provides a basis for the auto-generation of skirt pattern.

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