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Study on Individual Automatic Pattern Generation System

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Abstract: Based on extracting the basic sizes of human body automatically, this study develops 2D non-contact anthropometric and automatic pattern generation system of men's shirts and pants. The system needs the users to provide front and side photos of the consumers and carry interaction design of shirts or pants' styles. Then the patterns can be automatically generated based on the consumers' photos and the style design. Based on hybrid programming of VB.NET and MATLAB software, the two-dimensional anthropometric system is integrated with automatic pattern generation system. In this study, the students of Soochow University are chosen as subjects to do human body measurement. First, the front, side and back photos of human body are shot by digital camera. Then the point-cloud data are got by 3D body scanning and are measured by using Imageware software to get the rules of pattern generation. According to human silhouettes extracted by MATLAB and the rules of garment patterns, human sizes of main groups are automatically extracted and style design can be done with the silhouettes to generate patterns. This study can meet the individual demand of consumers and provides practical guidance to the application of 2D non-contact anthropometric system and the development of e-commerce in garment industry.

Key words: Automatic extraction, pattern generation, anthropometry

INTRODUCTION

Recently, the non-contact anthropometric technology has been put into use in related areas of many countries all over the world and parts of domestic institutions of higher learning and research institutes imported the non-contact measurement devices from abroad, to use for research on clothing. However, due to the difference of body type at home and abroad, high price and so on, the application and dissemination in domestic clothing industry still have considerable distance (Gu *et al*., 2011). Therefore, the research on non-contact anthropometric system has high practical value, which is easy and simple to handle, low cost and apply to clothing industry.

Pierre Meunier and so on advanced a measurement method based on 2D image. The reliability of auto-tagging algorithm, accuracy of measurement model can ensure better accuracy and reproducibility of measurement results (Meuniera and Yin, 2000). M.Dursun Kaya made use of Adaptive Neuro-Fuzzy Inference System (ANFIS) to predict the size (Kaya *et al*., 2003). Ken cai focuses on the measurement of body motion parameters and analysis method of body motion based on the theory of motion biomechanics. The contents involve the study on the relationship between parameters of motion biomechanics, the analysis of the law of body motion by measuring motion biomechanics parameters to provide theoretical guidance for recognition of human gesture, physical training and so on (Cai and Liang, 2011).

In the study of Chen (2011), body front photo and side photo were chose as objects. The extracted silhouettes of human body images were focused by using MATLAB software. The feature points on the silhouettes were determined based on the characters of bodily form. Then, body height, arm length, shoulder width, neck width, neck thickness, neck base width, neck base thickness, chest width, chest thickness, waist width, waist thickness, belt width, belt thickness, hip width and hip thickness were obtained.

According to the development of human civilization history, the garment demand has turned from the satisfaction of basic life, high quality and reasonable price into individuation and diversification. Moreover, when the consumer buys some clothes, she/he does not only want to see the appearance of the model, but also the 3D effect on herself/himself, so that it can be observed directly in computer that whether the clothes are fit or the colours are matching. The development of 3D garment CAD will make that possible.

Phoebe R. Apeagyei seeks to assess the application of 3D body scanning technology to human measurement for clothing provision and tests procedures for its

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implementation (Apeagyei, 2010). The methodology presents a case study approach involving the use of one such state-of-the-art technology in the acquisition of measurement data at a metropolitan university in the UK and advises on the application of the 3D body scanner in research and sampling activities.

Chang-Suk Cho and so on propose a garment-fitting system for an online retail model, which uses a consumer's 3 D body data for garment fitting (Cho *et al*., 2010). This system uses front and back images to model the garment and 3D laser scanned body data to model the body. In order to recognize characteristic points on the 3D body data, a moment template composed of central moments of vector angle sets on 3D body data is proposed and an implementation combining the 3D data and garment images is reported, which includes modeling, collision detection and feedback handling. The resulting system would support an online retail business model for garments. In the proposed business model, a body data center would scan the body and store the 3D data, the simulated garment-fitting program would be provided to individual consumers for fitting on a home PC and retail shops would exhibit garment images on their websites. In this proposed model, security of personal data and computational cost will not be an issue.

However, the engineering level at home has much difference with that abroad. But from the mid-eighty, some R and D institutions carried out researches on the development and study of garment CAD technology and have developed many GCAD systems, such as Beijing Institute of Clothing Technology, Zhongshan University, Hangzhou Aike Company, Shenzhen Yingning Company, Intelligent garment CAD design and fabric design system of Zhejiang University, HF-1 type garment CAD system of 710 department in Aeronautics And Astronautics, the Bili system of Beijing Technology and Business University and Xf-1 type garment CAD system of Xidian University and so on. They also developed the 3D garment design fitting system, which turned into commercialization (Luo *et al*., 2002; Zhao *et al*., 2000).

The garment mannequins can reflect certain human sizes and body type and is an important tool which can process clothing fabrication and display. 3D garment mannequin is important for the research of 3D garment CAD system. It can be said that 3D garment mannequins determine the direction of overall research system, difficulty Level and integrity, so the 3D and parameterized mannequins in computer become the technological base of 3D garment CAD and E-Commerce (Xia and Yao, 2008).

Based on automatic extraction of human body sizes, this paper developed automatic pattern generation system of men's shirts and pants. The specific demands are as follows: The user needs to provide front and side photos and makes individual design on the style. Then the system can automatically generate the patterns according to the body type and the shirts and pants' style of the user.

In this study, combined the 2D non-contact anthropometric system with automatic pattern generation system, the automatic anthropometry and pattern generation system is developed, which can meet individual demand of customers. The research results possess practical guidance to quick generation of individual pattern and the development of e-commerce in garment industry.

AUTOMATIC EXTRACTION

The fit is the necessary guarantee to keep the comfortableness of garment. In modern fashion industry, the design should satisfy the demand of different body type based on the characteristic of the consumer (11). The classification of local features will contribute to the rules establishment of pattern automatic generation, realize the tailor of massive individual clothes and promote the quick-reaction capability of the domestic clothing industry.

Subjects, apparatus and tools: Select male students (18-24 years old) of Soochow University as the research objects, whose height range is 160-180 cm. The sample number is no less than 300. In selection process of measuring objects, based on randomness of sample, the characteristic of these selected male bodies should fit the group structure features of female. That is to say, the normal body should be selected as far as possible.

In this research, two dimensional front and back digital camera photos are chose as objects, photos are processed by using image processing software PHOTOSHOP in order to extract human dimensions automatically in MATLAB. Automatic extraction of human dimensions based on two dimensional images is realized by using programming language of VB.NET. In order to simplify operations, it does not advocate open MATLAB software to do body size auto-extraction in the VB.NET form. So it can simplify operations by transferring M document in MATLAB to get a document which can directly read by VB.NET software and calling the document to do body size auto-extraction.

Photo processing: There are certain requirements for front and side human body photos provided by customers to realize auto-extraction of human dimensions in the interface environment of VB.NET. Human body silhouette

Fig. 1: Front and side photo

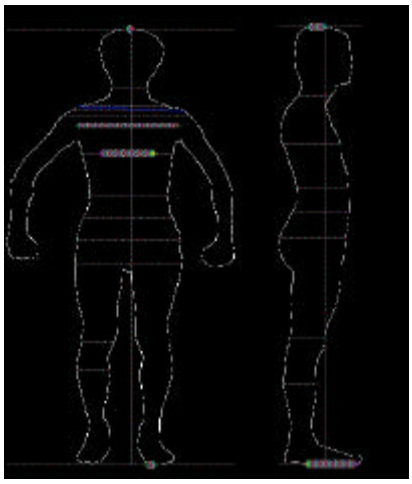

Fig. 2: Front and side silhouette

is identified firstly by auto-extraction procedure of human dimensions when processing photos, so contrast between human body and background need to big enough to reach the identifiable range of MATLAB. Therefore, human body images chose in this paper need to be processed by PHOTOSHOP, that is selecting human body, turning up the contrast and brightness and then anti-selecting the rest, setting the color black so that contrast between body and background is conducive to indentify body contour. The results of photo processing are showed in Fig. 1.

M file: In the research of auto-extraction of human dimensions, anthropometry is first. The extracted silhouettes of human body images were focused by using MATLAB software. The feature points on the silhouettes were determined based on the characters of bodily form. Then, body height, arm length, shoulder width, neck width, neck thickness, neck base width, neck base thickness, chest width, chest thickness, waist width, waist thickness, belt width, belt thickness, hip width and hip thickness were obtained. And then body data auto-generation can be realized. The procedure document called is M file.

Taking hip girth as an example, extraction process of hip girth size is produced as following (Table 1).

Body size Auto-extraction in MATLAB: Body size of front and side photos can be auto-generated by calling M file in MATLAB software. Figure 2 are the extraction results, which show that body silhouette can be extracted accurately. Based on human silhouettes extracted by MATLAB, automatic extraction of human sizes of main groups is realized, which include body height, chest thickness, waist thickness, hip thickness, belt thickness, knee thickness, calf thickness, chest width, waist width, hip width, belt width, thigh width, knee width, calf width, shoulder curve, B-P width, max back width, arm length, neck width, thigh thickness, neck thickness and other data, to provide basic data for pattern auto-generation. Then the classification is done according to the ratios of the thickness and width (ratio = thickness/width), so the girth of each position in each category is fitted according to fitting formulas (Table 2).

MATLAB procedure transformation:

- **Conversion reasons**

The realization of auto-extraction of human dimensions based on two-dimensional images is using VB.net programming language. In this process, completion of auto-extraction of body size needs to call M file in MATLAB software. In actual application, users need to install MATLAB and VB.net software as well as to learn how to call program to extract body size which is complex and reducing the feasibility and convenience of operation. Therefore, in order to simplify operations, it does not advocate open MATLAB software to do body size auto-extraction in the VB.net form. So it can simplify operations by transferring M document in MATLAB to get a document which can directly read by VB.net software and calling the document to do body size auto-extraction

- **Conversion process**

Table 1: Extraction process of hip circumference size

	Hip-width	Hip-thickness	Hip girth
Method	(1) Find hip conflict points in side silhouette (2) Find left and right points of hip height in front silhouette (3) Calculate distance between two points	(1) Find hip conflict points in side silhouette (2) Find the other point in the line of hip height (3) Calculate distance between two points	Calculate hip girth according to fitting equation
Procedure	for j = u3:-1:1 if bw3a (I, j) = = 0 c11 = j break end end for k = u3:1:n if bw3a (i,k) = = 0 c22=k; break end end c33 = i hip-width = abs (c22-c11)	for j = u3:-1:1 if bw3b(i, j) = = 0 c1 = j break end end for k = u3:1:n if bw3b (i, k) = = 0 c2 = k, break end end c3 = i hip-thickness = abs (c1-u3);	Hip girth #NAME? +B*hip-thickness+C

Table 2: Fitting equations of each part

Frm of fitting equations: $Y = a_0+a_1*thickness+a_2*width$

Part	Ratio	A_0	A_1	A_2	Part	Ratio	A_0	A_1	A_2
Neck	0.86-0.90	19.932	2.135	-0.845	Bust	1.11-1.20	-3.916	3.640	-0.007
	0.91-0.95	12.722	2.045	0.031		1.21-1.30	14.509	2.817	0.227
	0.96-1.00	21.979	1.679	-0.376		1.31-1.40	11.579	1.608	1.281
	1.01-1.05	23.637	0.206	0.943		1.41-1.50	22.953	1.982	0.665
	1.06-1.10	29.351	1.405	-0.660		1.51-1.60	39.395	4.650	-1.597
	1.11-1.15	25.031	2.892	-1.593		1.61-1.70	15.240	6.240	-1.607
Waist	1.11-1.20	8.969	-8.826	8.700	Abdomen	1.21-1.30	5.340	3.903	-0.376
	1.21-1.30	0.321	-0.393	10.070		1.31-1.40	-0.678	1.236	1.897
	1.31-1.40	-1.853	0.639	3.198		1.41-1.50	11.948	3.939	-0.443
	1.41-1.50	3.482	1.534	2.382		1.51-1.60	4.191	1.371	1.633
	1.51-1.60	7.150	0.722	1.536		1.61-1.70	13.909	2.257	0.710
Hip	1.11-1.20	-25.546	-5.862	8.700	Thigh	0.75-0.80	-18.567	4.378	-0.610
	1.21-1.30	1.120	1.870	1.325		0.81-0.85	11.662	4.228	-2.127
	1.31-1.40	7.832	2.442	0.696		0.86-0.90	10.511	1.904	0.707
	1.41-1.50	16.623	1.434	1.194		0.91-0.95	9.498	1.614	1.116
	1.51-1.60	80.518	-5.273	3.442		0.96-1.00	22.036	-0.350	2.319
						1.01-1.05	16.823	2.531	-0.168
Knee	0.76-0.80	17.475	0.797	0.664	Calf	0.76-0.80	11.269	1.188	0.940
	0.81-0.85	20.414	1.448	-0.338		0.81-0.85	4.895	1.212	1.606
	0.86-0.90	16.755	-1.179	3.005		0.86-0.90	7.269	0.849	1.807
	0.91-0.95	20.593	1.940	-0.805		0.91-0.95	7.741	-0.039	2.736
	0.96-1.00	21.590	2.674	-1.551		0.96-1.00	15.164	2.276	-0.416

In MATLAB software, M file can be transferred to COM file directly called by VB.net software by setting environment variables:

- Install MATLAB and VB.net software
- Set environment variables
- Open MATLAB software and converse M file to COM file
- Conversion procedure: mex _setup, mbuild _setup and comtool

PATTERN GENERATION

Mathematical models: Anthropometry is the basis of human somatotype and custom-tailored outfits and also is necessary means to grasp characteristic of the contemporary human body correctly. Whether the measured data are precise directly affects the rationality of somatotype and the specification and quality of clothing. According to the regulations on the human body posture of anthropometry, get the point-cloud figure of the studies through scanning the human body by 3D body scanning device (symcad) and read and optimize the point-cloud data by imageware software. Get the data of the necessary parts by picking up the feature points of the human body.

According to architectural feature of human body, sizes of front and back pieces of clothes are different, so whole girths of characteristic positions need to be divided

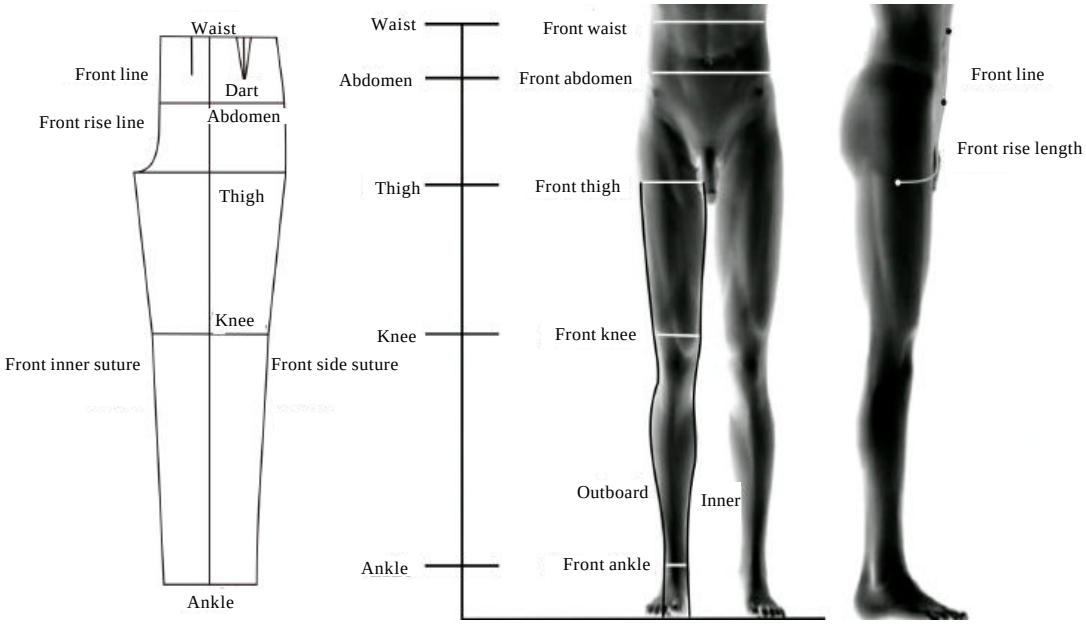

Fig. 3: Structure chart of front piece and schematic diagram of anthropometry

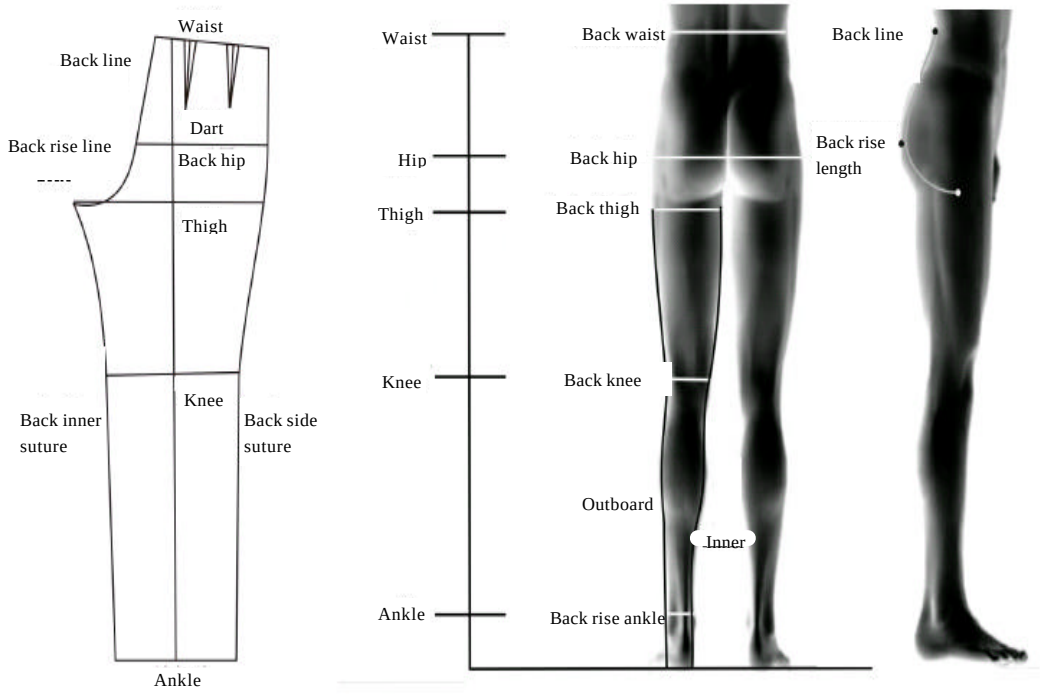

Fig. 4: Structure chart of back piece and schematic diagram of anthropometry

into front and back girth. The necessary sizes to draw pattern are calculated and the mathematical models of each position are built (Table 3).

Rules of pattern: The key positions of changed style, the necessary human measured data and the relationships between these data and structure lines of pants are found out by theoretical analysis (Fig. 3-4). The necessary

Table 3: Mathematical models of each position

Independent variable X	Dependent variable Y	Y= a+bX a	Sig.a	b	Sig.b
Waist	Front waist	7.229	0.000	0.393	0.000
Abdomen	Front abdomen	9.040	0.000	0.376	0.000
Hip	Back hip	-1.995	0.599	0.539	0.000
Thigh	Front thigh	-0.757	0.750	0.531	0.000
Knee	Front knee	6.635	0.016	0.234	0.000
Ankle	Front ankle	8.868	0.000	0.089	0.000

Table 4: Relationships between human data and structure lines of shirts

Structure lines of patterns	Parameters of human body: Crosswise	Lengthways
Bust line	Bust girth	Bust height
Waist line	Waist girth	Waist height
Bust width line	Bust width	Bust width height
Across back line	Across back width	Across back height
Front centre line		Front centre length
Back centre line		Back centre length
Side seam line		Side seam length
Neck line	Neck girth	
Armhole line	Arm girth and width	
Shoulder line	Shoulder length and width	

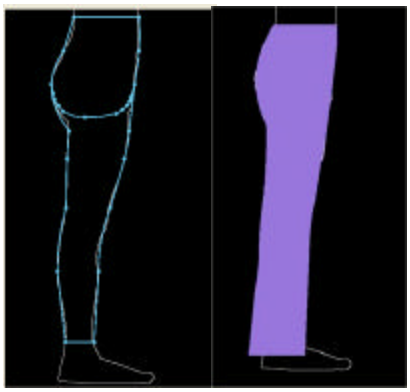

Fig. 5: Ganged style design of pants

human measured data and the relationships between these data and structure lines of shirts are found out by theoretical analysis (Table 4). Then through the draping test, the relationships between basic pattern and measured data are got and the effect law of trend change to basic pattern is got to achieve the rules of basic pattern.

System development: The generation rules of ganged style design are constructed by setting modeling parameters. According to related rules of each position, program can be done to realize ganged style design and pattern generation (Fig. 5-6).

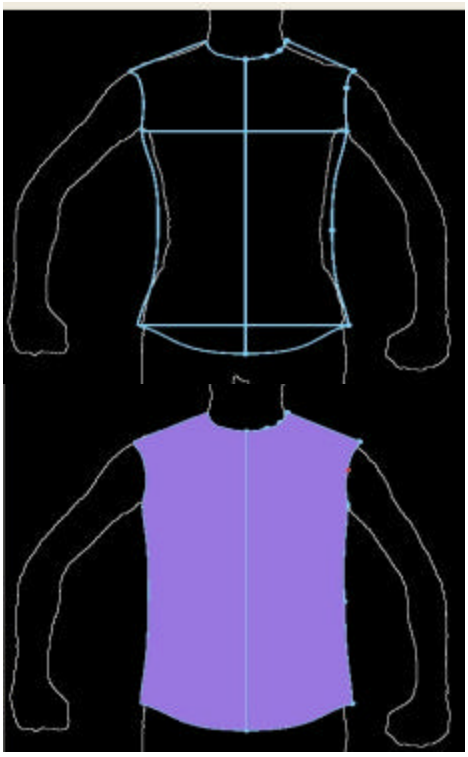

Fig. 6: Ganged style design of shirts

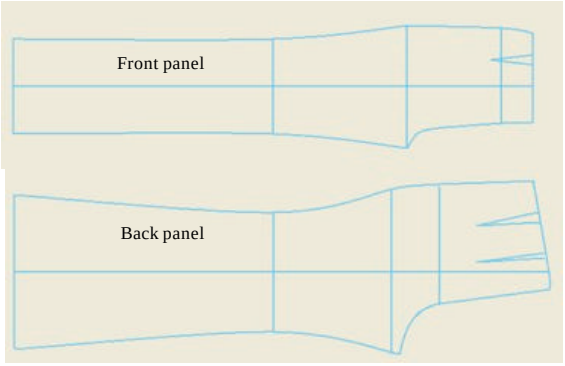

Fig. 7: Patterns of the above pants

Combination of measurement and pattern: The anthropometry system can be combined with automatic pattern generation system by programming and the automatic anthropometry and pattern generation system is developed, to realize automatic ability with real content. The patterns of the above pants and shirt are shown in Fig. 7-8.

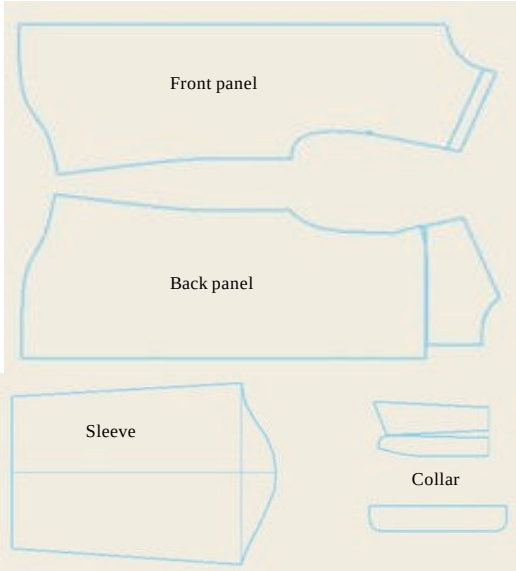

Fig. 8: Patterns of the above shirt

CONCLUSION

In this study, automatic extraction of human sizes is studied. And based on that, automatic pattern generation of men's shirts and pants is developed. The definite research results are as follows:

- Based on front and side photos of human body, through extraction of silhouettes and direct sizes, determination of key points, fitting formulas and other studies, 2D non-contact anthropometry technology are realized
- Individual design is done on shirt's style and then according to the body type and the shirts and pants' style of the user, the system can automatically generate the patterns of shirts, so automatic pattern generation of men's shirts and pants is realized
- The anthropometry system can be combined with automatic pattern generation system by programming and the automatic anthropometry and pattern generation system is developed, so it can meet individual demand of the customers

The research results possess practical guidance to quick generation of individual pattern and the development of e-commerce in garment industry.

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