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Automatic Generation Method of Different Stand Collar Patterns ⋆

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Abstract

As technology continues to advance, there is a growing interest in personalized customization with diverse styles and a high degree of fit. To address challenges such as long production cycles and high labor and material costs associated with personalized customization, there has been significant research on automatic pattern generation. However, most of these studies focus on relatively single garment styles. Therefore, this paper proposes a method for automatically generating multi-style collar patterns. First, by analyzing the characteristics of stand collar styles, the modules of stand collar are determined, and the control attributes and methods of each module are determined according to the actual needs. Based on this, a modular design method for stand collar is constructed; the neck parameters and stand collar structure are statistically analyzed, and a mapping model between neck parameters and stand collar structure is established; then, the relationship between stand collar modules and paper patterns is analyzed, and a relationship model between numerical control modules and paper pattern parameters is established to achieve the purpose of driving stand collar structure parameters by stand collar styles; then, according to the stand collar structure design method, the key points of the pattern are parameterized, thus realizing the parametric design of the stand collar pattern; finally, using Matlab software, different components are coordinated, and the modular design method and parametric design of stand collar are comprehensively applied to realize the automatic generation of different styles of stand collar patterns. The research shows that the automatic pattern generation method established in this paper can meet the automatic pattern generation of different stand collar styles, and reduce some human and material costs for the pattern making process in the clothing industry.

Keywords: Stand Collar; Garment Modular Design; Parameterized Design; Automatic Pattern Generation

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1 Introduction

The collar is an essential element of the overall modeling of clothing, as it connects the head and the body visually, and reflects the beauty and quality of the garment. Stand collar is a common type of collar, whose appearance directly influences the style and quality of the clothing [1, 2]. To design different Stand collar models, it is necessary to analyze the relationship between the collar structure parameters and the modeling in depth. Moreover, the human neck structure is the basis of the stand collar structure design, and the stand collar structure design should be based on the individual neck structure [3]. The advantage of personalized customization is that it offers diverse styles and high fit, but the slow production cycle is the biggest drawback of customized clothing, and also a major obstacle for the development of personalized clothing [4]. Fortunately, the development of three-dimensional virtual clothing has improved the efficiency of the clothing design process to some extent, and the clothing size customization recommendation based on knowledge discovery and data mining has reduced the error of human body measurement and improved the fit of the clothing [5-8]. However, in personalized clothing customization, the measurement and production of clothing are highly intelligent, but the clothing pattern is still mainly made by manually operating CAD software, lacking intelligence and innovation [9, 10]. Therefore, establishing a system that can automatically generate clothing patterns has important significance and value for personalized clothing customization. At present, the research on stand collar mainly focuses on the influence of stand collar structure parameters on stand collar modeling [11], the relationship between neck modeling and stand collar structure related variables [12], and the correlation between neck circumference, collar height, collar tightness, and neck movement [13], which provide guidance for the modeling design and fit improvement of stand collar. The automatic pattern generation technology of clothing has improved the efficiency of pattern making to some extent, avoided tedious processes, and provided new ideas for the intelligent manufacturing of clothing [14]. The automatic pattern making technology of clothing includes two methods: parametric drawing and artificial intelligence clothing structure design, among which parametric drawing is more suitable for personalized customization [15]. At present, the more mature research in the academic world is to set a series of parameters for a drawing method, and apply geometric constraints or assignment constraints to the paper pattern, and directly generate the corresponding paper pattern, but one geometric constraint or assignment constraint can only correspond to one style, which makes this method have certain limitations [16]. In order to improve the applicability of the style, clothing scholars began to propose a parameterized paper pattern automatic generation model for various clothing styles. Based on geometric constraints or assignment constraints, the parameter setting of style changes is proposed to increase the universality of the paper pattern automatic generation model [17]. However, the parameterized paper pattern automatic generation model still cannot meet the needs of personalized clothing for style diversity. Introducing the clothing modular design method can effectively solve this limitation and enrich the clothing style [18].

This paper proposes a parametric design method for stand collar pattern, and constructs automatic pattern generation for different stand collar styles. The method consists of the following steps: using statistical analysis to establish a mapping model between human neck and stand collar structure parameters; developing a modular design method for stand collar, and creating different stand collar styles by combining different modules; Using the Matlab software to achieve the variety of stand collar design is automatically generated.

2 Method

The analysis of the conventional shirt collar, the model division of the stand collar style, the determination of the control attributes and methods of the stand collar module, based on this, the modular design method of the stand collar style is determined; the analysis of the neck forward tilt of the body type characteristics, the introduction of the stand collar structure parameter rotation angle, the stand collar structure optimization method is proposed, and the mapping model of the neck and the stand collar structure parameters is established, to improve the fit of the stand collar pattern; by regression analysis, the relationship model between numerical control modules and paper pattern parameters is determined. Finally, using the parametric design method, according to the stand collar structure design method, the stand collar paper pattern automatic generation method is established, The framework of the pattern automatic generation method is shown in Fig. 1.

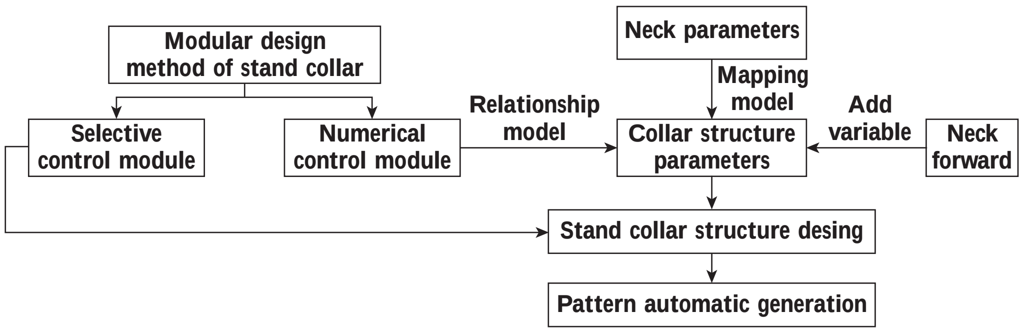


Fig. 1: Framework of the pattern automatic generation method

2.1 Mapping Model

2.1.1 Pattern Correction Method

Compared with the normal body's neck backward inclination angle, the neck backward inclination angle of the neck forward is larger. When the people with neck forward wear the clothing of the standard body type, there will be too much space in the back of the neck, while the front of the neck is close to the stand collar, causing discomfort. The dress difference between normal body and neck forward is shown in Fig. 2.

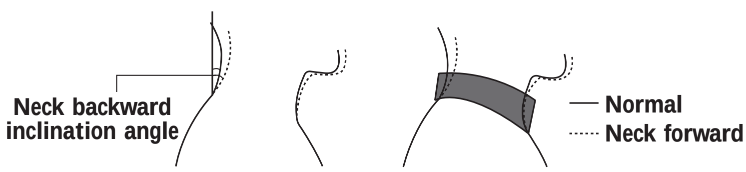


Fig. 2: Difference between normal body and neck forward

In order to improve the fit between the neck and the back of the collar, rotate the collar lower line at a certain angle(γ) to form a new standing collar structure design method, as shown in Fig. 3.

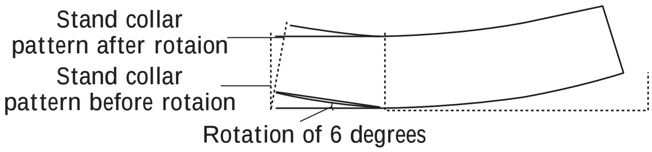
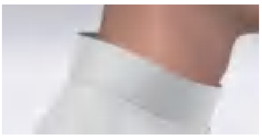


Fig. 3: Design method of standing collar structure

Fig. 4(a) shows the virtual try-on before the adjustment of the stand collar structure, the stand collar has a large gap at the back neckline. Fig. 4(b) shows the virtual try-on after the adjustment of the stand collar structure, the stand collar is more fitted. Therefore, γ is chosen as one of the structural parameters of the stand collar.



(a) Virtual try-on picture before adjustment of stand collar structure

(b) Virtual try-on picture after adjustment of stand collar structure

Fig. 4: Virtual try-on picture before and after adjustment of stand collar structure

2.1.2 The Relationship between the Neck and Stand Collar Modeling

The stand collar modeling is affected by the circumference, angle, and length of the neck, as well as by the structural parameters of the stand collar. Based on this relationship, a conversion model of the neck parameters to stand collar structure parameters can is established. The definitions of the neck parameters and the stand collar modeling parameters are shown in Table 1.

As shown in Fig. 5, the collar lower line depends on the neck root circumference and certain ease1. The collar upper line depends on the neck middle circumference and certain ease 2. The Parameter formula is shown in Eq. (1).

$$\mathrm{L} = \mathrm{a} + \mathrm{c1} - \mathrm{b} - \mathrm{c2} \tag{1}$$

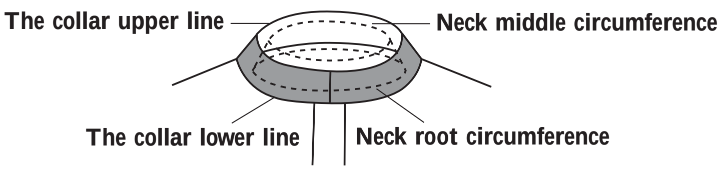


Fig. 5: Girth relation between neck and standing collar

As shown in Fig. 6, the neck backward inclination angle depends on The collar backward inclination angle and The neck back gap amount. the Parameter formula is shown in Eq. (2).

$$\beta = \alpha - \mathrm{c3} \tag{2}$$

Table 1: The definitions of the neck parameters and stand collar modeling parameters

Parameter category	Parameter name	Symbol	Definition
Neck parameter	Neck root circumference	a	The circumference of the root part of the neck
	Neck middle circumference	b	The circumference of the middle part of the neck
	Ease1	c1	An ease to the neck root circumference
	Ease2	c2	The ease to the middle part of the neck
	Neck back gap amount	c3	The distance between the back of the neck and the collar of a stand collar side view diagram
	Neck backward inclination angle	α	The angle between the back of the neck and the vertical line of a stand collar side view diagram
Stand collar modeling parameters	Collar backward inclination angle	β	The angle between the back collar line and the vertical line of a stand collar side view diagram
	difference	L	The difference between the length of the collar upper line and collar lower line of a stand collar

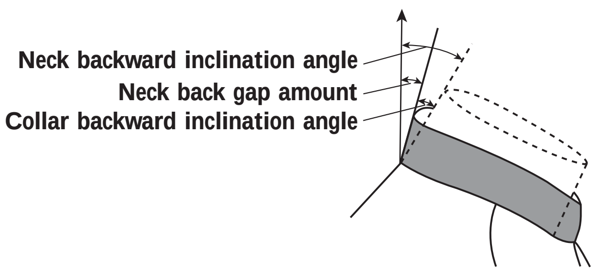


Fig. 6: Angle relation between neck and stand collar

2.1.3 The Relationship between Stand Collar Construction and Modeling

To build the conversion model of the neck and stand collar structural parameters, this paper uses collar height, collar girth, center front upwarp, and the introduced variable (γ) as experimental independent variables, and difference (l) and Collar backward inclination angle (β) as dependent variables. Collar height, collar girth, and center front upwarp are represented by h, n, and i respectively. The value selection of the independent variable is shown in Table 2. The five horizontal variables make up 600 sets of experimental data.

Table 2: Numerical selection of experimental variables

Independent variable	Numerical value
Collar girth (cm)	38, 39, 40, 41
Collar height (cm)	1, 1.5, 2, 2.5
Center front upwarp (cm)	2.5, 3,3.5, 4, 4.5
Rotation angle (°)	0, 2, 4, 6, 8, 10

By calculating the Pearson's correlation coefficient between the stand collar structure parameters and the stand collar modeling, the correlation between the two parameters can be measured. The correlation between the stand collar structure parameters and the stand collar modeling parameters is shown in Table 3.

Table 3: Correlation coefficient between structural parameters and modeling parameters

Structural parameters	Collar girth	Collar height	Center front upwarp	Rotation angle
Collar upper line	0.738	−0.401	−0.277	−0.430
Collar lower line	0.964	0.002	0.239	0.074
Difference	−0.078	0.504	0.507	0.604
Collar backward inclination angle	−0.344	−0.112	−0.032	0.782

The Pearson's correlation coefficient can only analyze the correlation between two variables, and it may be biased by the effect of other variables. To evaluate the true correlation between two variables more accurately, it is essential to consider and control the impact of other variables. The collar lower line is correlated with the collar height and center front upwarp, and the difference is correlated with center front upwarp, the rotation angle, and the collar height. The collar backward inclination angle is correlated with the rotation angle, the collar girth. By exchanging control factors, partial correlation analysis can be conducted. The analysis results are shown in Table 4.

Table 4: Partial correlation analysis

Dependent variable	Control variable	Independent variable	Correlation coefficient
Collar lower line	Center front upwarp	Collar girth	0.993
	Collar girth	Center front upwarp	0.9
Difference	Collar height, Center front up warp,	Rotation angle	0.863
	Collar height. Rotation angle	Center front upwarp	0.821
	Center front upwarp, Rotation angle	Collar height	0.819
Collar backward inclination angle	Rotation angle	Collar girth	0.837
	Collar girth	Rotation angle	−0.566

Based on the correlation analysis and partial correlation analysis, the collar lower line is mainly influenced by the collar girth and center front upwarpt. The regression analysis of these three variables is shown in Table 5. From this, the relationship model of the collar lower line (L1) as a function of the collar girth (n) and the center front upwarp (i) is shown in Eq. (3).

$$L1 = 0.976n + 0.383i - 0.727 \tag{3}$$

Based on the correlation and partial correlation analysis results, the regression equations between other modeling parameters and structural parameters can also be obtained, as shown in Eq. (4) and Eq. (5).

$$\beta = 1.459\gamma - 1.964n + 93.035 \tag{4}$$

$$L = 0.228\gamma + 0.925i + 0.918h - 2.937 \tag{5}$$

Table 5: Results of the regression analysis

Model	Regression coefficient	Standard error	T-value test	Significance level
Collar girth	0.976	0.005	202.965	0.000
Center front upwarp	0.383	0.008	202.965	0.000
Constant	0.727	0.191	3.813	0.000

To summarize, this paper builds a conversion model between the human neck parameters and stand collar structure parameters. The conversion model of the human neck and stand collar structure is summarized are shown in Eqs. (6)-(7).

$$\alpha - \mathrm{c3} = 1.459\gamma - 1.964n + 93.035 \tag{6}$$

$$\mathrm{a} + \mathrm{c1} - \mathrm{L1} = 0.228\gamma + 0.925i + 0.918h - 2.987 \tag{7}$$

2.2 The Relationship between Style and Pattern of Stand Collar

2.2.1 The Modular Design of the Stand Collar

The regular stand collar has low stand collar, neutral stand collar, high stand collar, buckle stand collar, no buckle stand collar, square corner stand collar, round corner stand collar. As shown in Fig. 7, the design of the conventional standing collar mainly comes from the height of the collar, the amount of overlap in the front center, and the form of the collar angle. Therefore, the style of standing collar is divided into four modules: collar angle, collar height, The collar front topper apex module, the collar front lower apex module.

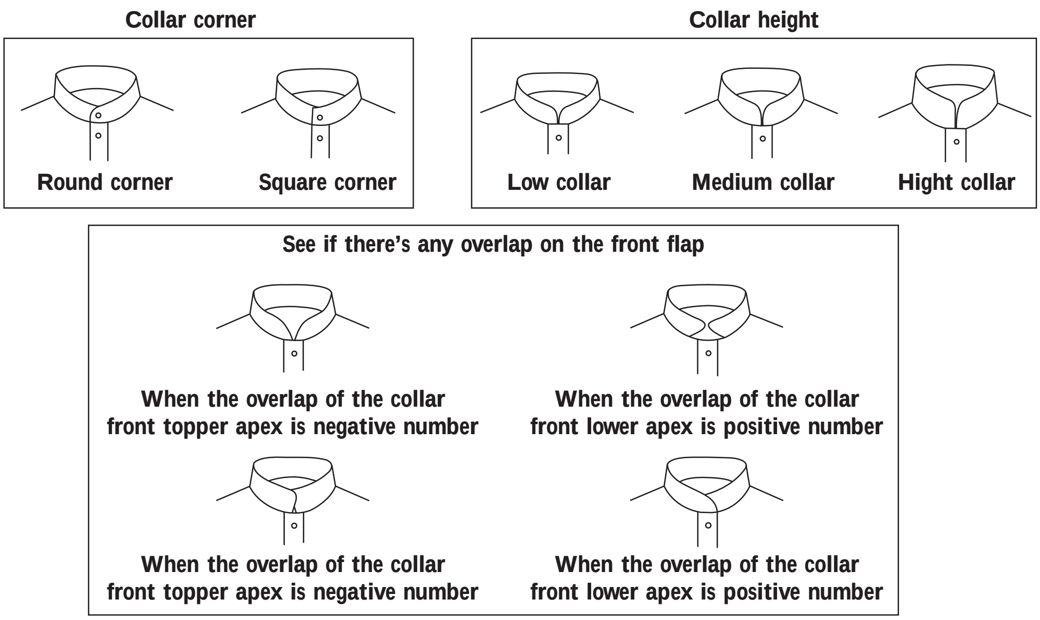


Fig. 7: Stand collar module division

The collar front topper apex module and the collar front lower apex module refer to The opening and closing amount before standing collar, it is controlled by numerical values; the collar height module refers to the height of the stand collar, which has three control attributes: low stand collar, medium stand collar and high stand collar; the collar corner module refers to the shape of the stand collar corner, which has two control attributes: round corner and square corner. Collar front topper apex module and collar front lower apex moduler are numerical control methods, while Collar corner module and collar height module are selection control methods. The modular design method of the stand collar is shown in Table 6.

Table 6: Modular design of the stand collar style

Submodule	Control attributes	Control methods
Collar front topper apex module	Collar front topper apex	Numerical value
Collar front lower apex module	Collar front lower apex	Numerical value
Collar corner module	Round corner, Square corner	Selection
Collar height module	Low collar, Medium collar, High collar	Selection

2.2.2 The Relationship Model between the Numerical Control Module and Pattern

The control forms of the stand collar are divided into numerical control and selective control. The selective control modules can directly generate the stand collar patterns, while the numerical control modules require a relationship model to convert the numerical modules into the stand collar patterns.According to the modular design of the stand collar, the numerical control modules of the stand collar is the collar front topper apex module and the collar front lower apex module.

The collar front topper and lower apex module indicate the opening and closing amount of the left and right standing collar. Let the opening and closing quantity of the collar front topper apex be f, and the opening and closing quantity of the collar front lower apex be g As shown in Fig. 8(a), the collar front topper apex changes by moving point C in the pattern along E3C by a distance of d_c. As shown in Fig. 8(b), the collar front lower apex changes by moving point D in the pattern along E4D by a distance of d_d.

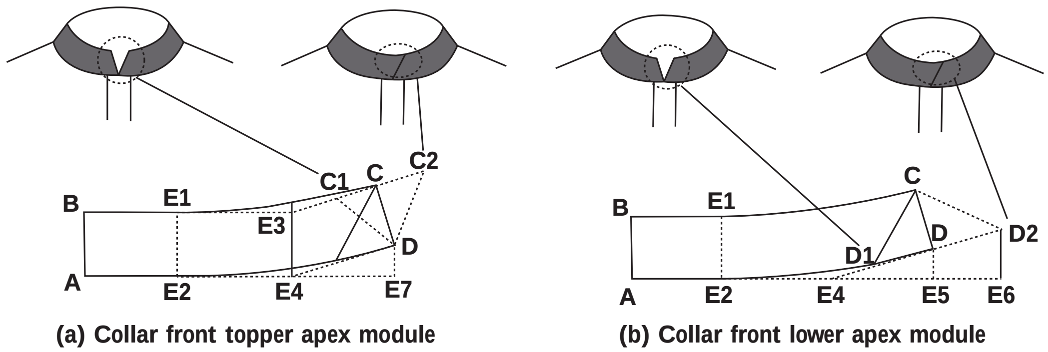


Fig. 8: Relationship between collar front topper and lower apex module and the structure

To convert the collar front topper apex (f) to the amount of movement of point C on the pattern (d_d), establishing a relationship model between f and d_d is necessary. Under the conditions of a neck circumference of 40 cm, the center front upwarp of 1.5 cm, and the collar height of 3.5 cm, point C moves 1 cm from point E3 each time, fifteen pattern samples were drawn using ET software and imported into 3dclo. Subsequently, virtual fittings were conducted using the same fabric, and the opening and closing quantity was measured using 3dclo's built-in straight-line measurement tool. The measurement method of opening and closing quantity is shown in Fig. 9.

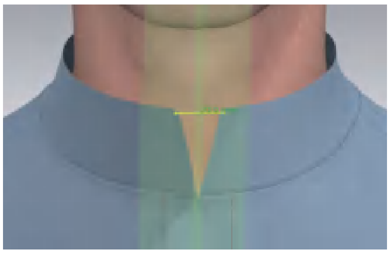


Fig. 9: Measurement method of opening and closing quantity

According to the statistical regression analysis conducted in SPSS 2020, it examined the relationship between the collar front topper apex (f) to the amount of movement of point C, the results are presented in Table 7. The probability (p-value) from the significance test is less than the significance level ($\alpha = 0.05$), indicating that the amount of movement(d_c) in the model has a statistically significant impact on the opening and closing amount (f). The relationship model between the amount of movement of point C(d_c) and the collar front topper apex (f) is shown in Eq. (8).

$$d_c = 0.604 \times f + 6.309 \tag{8}$$

Table 7: Regression model of f and d_c

Model	Regression coefficient	Standard error	T-value test	Significance level
f	0.604	0.145	43.481	0.000
Constant	6.309	0.018	32.614	0.000

By employing a similar approach, the relationship model can be established between the opening and closing amount at the collar front topper apex (g) and the amount of movement of point C on the pattern (d_d). The represents this relationship is shown in Eq. (9).

$$d_d = 0.561 \times g + 6.924 \tag{9}$$

2.3 Parametric design of Stand Collar Pattern

The key points of the standing collar pattern is shown in Fig. 10. Based on the stand collar structure design and the relationship between the angles in the geometric figure, the horizontal and vertical coordinates of each key point in the stand collar pattern can be calculated. Table 8 shows the parameterization of the key points of the stand collar pattern, where Q denotes the length of DE4, the length formula of Q is shown in Eq. (10).

$$\mathrm{Q} = \sqrt{(n/6)^2 + (i)^2} \tag{10}$$

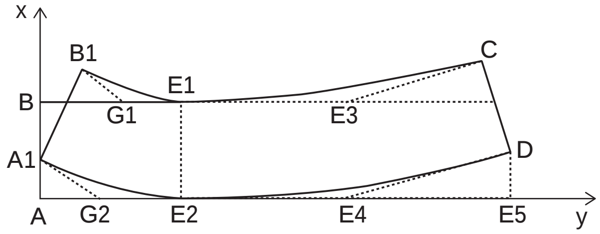


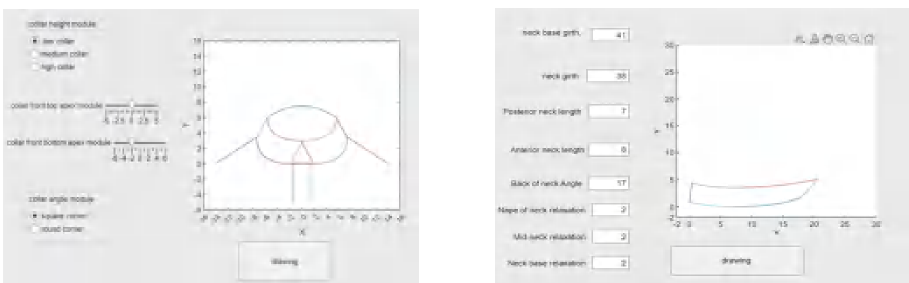
Fig. 10: The key points of the stand collar pattern

Table 8: Parameterization of key points of stand collar pattern

Point	X	Y
A1	0	$1/6\ n \tan a$
B1	$h \sin a$	$h \cos a + 1/6n \tan a$
E1	n/6	h
E2	n/6	0
E3	n/3	h
E4	n/3	0
E5	n/2	0
G1	n/12	0
G2	n/12	h
C	$\frac{(1/6n+1)/6nd_c}{\sqrt{(1/6n-hiI/Q)^2+(I+hn/6Q-h)^2}} + 1/3n$	$\frac{(I+nh/6Q-h)d_c}{\sqrt{(1/6N-hi/Q)^2+(i+nh/6Q-h)^2}}$
D	$1/3n + d_d n/6Q$	$d_d i/Q$

2.4 Automatic Pattern Generation

As shown in Fig. 11, the automatic generation of stand collar patterns is realized through the style selection interface and the pattern generation interface. Different stand collar styles can be created by selecting different modules, and the style information is transferred to the pattern generation interface by programming. In thepattern generation interface, the individual neck data and the relaxation amount are entered, and different stand collar paper patterns can be generated by clicking drawing.



(a) Style selection interface (b) Pattern generation interface

Fig. 11: Automatic stand collar pattern generation

3 Results

3.1 Comfort Test

The rapid development of virtual technology in the field of clothing design provides a more innovative way to evaluate clothing comfort. In this study, a virtual stress test was used to analyze the fitness of clothing patterns. The automatically generated patterns was imported into 3Dclo software for virtual try-on. Figure 12 shows the schematic diagram of the virtual pressure test.

Fig. 12: The schematic diagram of the virtual pressure test

Observe Fig. 12, stand collar, no folds, no deformation. The pressure of the whole standing collar is calculated, and the pressure value of the standing collar is between 0.02 and 4.31, it is within the comfortable range of the human neck. Among them, the place where the pressure value is larger is mainly located at the position of the left and right shoulder and neck point, mainly because the left and right shoulder and neck point is the bearing point.

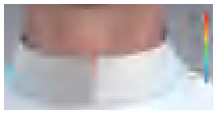
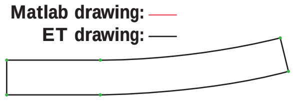
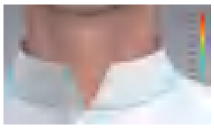
3.2 Different Styles of Pattern Generation

ET is a common software for drawing patterns, and the drawn patterns have high accuracy.In order to verify the accuracy of the linear fitting of different styles of stand collar patterns,choose three stand collars, and their module information is shown in Table 9. Three different styles of stand collar patterns were drawn using the pattern automatic generation interface developed by Matlab software and ET software, respectively. The stand collar patterns drawn by ET and Matlab were overlapped by scaling the same proportion, and the degree of overlap between them was observed. As can be seen from Table 9, for the same specifications of stand collar patterns, the ones drawn by Matlab are basically consistent with those drawn by ET.The garment changes from blue to red, and the pressure value of the garment increases. The pressure diagram of the three types of standing collar is white as a whole and blue as a part, indicating that the overall pressure value is low. Therefore, the paper pattern of standing collar generated by this method has certain comfort.

4 Discussion

In recent years, there has been a growing trend towards personalized and customized clothing. Consumers are increasingly seeking unique and individualized garments that reflect their personal

Table 9: Comparison of different styles of Matlab and ET plate making

Style	Module information	Pressure diagram	Comparison diagram
A	Collar front topper apex module: 0 cm Collar front lower apex module: 0 cm Collar corner module: square angle Collar height module: medium collar		
B	Collar front topper apex module: 5 cm Collar front lower apex module: 0 cm Collar corner module: square angle Collar height module: medium collar		
C	Collar front topper apex module : −5 cm Collar front lower apex module: 0 cm Collar corner module:square angle Collar height module: medium collar		

style and preferences. This trend has created new challenges for the fashion industry, as traditional methods of mass production are not well-suited to the production of customized garments. The main contribution of this paper lies in proposing an automatic pattern generation method, which provides both theoretical and practical foundations for generating clothing patterns across multiple styles. Compared with previous studies, this paper extends the method of automatic pattern generation to adapt to various styles. By increasing the speed of plate making, while meeting the needs of consumers for different styles.However, this paper also has some limitations that need to be addressed in future work. First,this paper only completes the stand collar pattern automatic generation, and does not verify the applicability of this method for the whole garment pattern automatic generation. Second, this paper still relies on manual input of human body data and does not implement the photo measurement technology that can automatically read the measurement data. The future work direction is to extend the method proposed in this paper to the whole garment paper pattern automatic generation, and combine it with the photo measurement technology, to achieve the comprehensive intelligence of paper pattern automatic generation.

5 Conclusions

Based on the principles of parametric design, a method for automatically generating clothing patterns has been proposed. A mapping model was constructed to convert neck measurements into structural parameters for generating a well-fitted collar pattern. The stand collar was divided into different modules, and control attributes and methods were determined based on practical requirements. By analyzing the relationship between style variations and patterns, the stand collar module was transformed into the corresponding structural design. This method for automatically generating stand collar patterns not only applies to various stand collar styles but also enhances the fit of stand collar patterns. It provides a theoretical foundation for establishing an automatic system for generating stand collar patterns. However, this paper also has some limitations that need to be addressed in future work. First, this paper only focuses on the stand collar pattern and does not take into account the complete pattern of a whole garment. Second, this paper still depends on manual input of human body data and does not incorporate the photo measurement technology that can automatically read human body data.

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