www.cadanda.com Computer-Aided Design AND APPLICATIONS

Design and Implementation of a Component-based Intelligent Clothing Style CAD System

Lan Hu

School of Art, Chongqing Technology and Business University, Chongqing, 400067, China, hulan216@163.com

Corresponding author: Lan Hu, hulan216@163.com

Abstract. Since the birth of the clothing CAD, it has been constantly updated and developed rapidly. The development of intelligent clothing to meet the needs has become a new trend and research direction. This article presents a design framework for a component-based intelligent clothing style CAD system. By dividing clothing into different components, each component becomes a relatively independent design unit. This article first analyzes the current development status of apparel CAD software at home and abroad, and points out that the development of apparel CAD software is immature and has become the bottleneck of apparel production processes. Then use the structural characteristics of the clothing to divide the clothing style into a combination of several parts. The design flow and functions of the intelligent style design system are analyzed, and based on this, the system architecture is designed. Finally, a new intelligent style design architecture is proposed to support the style element component design method. Beneficial exploration of the intelligent design of clothing styles has laid a good foundation for the further realization of fully automated style design.

Keywords: Intelligent Clothing CAD; Intelligent Stitching; Style Design
DOI: https://doi.org/10.14733/cadaps.2021.S1.22-32

1 INTRODUCTION

Computer Aided Design (CAD) is an emerging comprehensive computer application system technology that has developed rapidly in the past 50 years. It uses the powerful computing capabilities of computers and high-efficiency graphics processing capabilities to assist in the completion of design. Zhou et al [1] said calculation, analysis, simulation, drafting, and preparation of technical documents are a specialized technology for computers to help designers implement product design and engineering design.

In the late 1960s, Professor Ivan E. Sutherland of the Massachusetts Institute of Technology used the term "Computer Graphics" for the first time, confirming the independent status of computer graphics as a new branch of science. Mok et al [2], as a result, computers not only can perform scientific calculations and word processing, but also have the ability to process and display graphics, opening the way for the development of CAD technology. After more than 30 years of development of CAD technology, it has been widely used in engineering design and product design of various industries in developed countries. Lee et al [3], it has pioneered the combination of computer applications and traditional industries, and also laid the foundation for the development of advanced information technology and its industrialization. In this regard, in the 1993 United States Technology Forecast and Evaluation Data Report, CAD technology was rated as one of the top ten key technologies in the 20th century; in 2001, the American Futurology Magazine reported that CAD technology was listed as an economic issue in the first 20 years of the 21st century One of the 13 key technologies that have the most influence on social development.

Computer Aided Garment Design (referred to as GAGD, also known as clothing CAD) is a modern technology for humans to use computer as a modern tool to complete all aspects of clothing design. Clothing CAD technology started late, in the 1980s Computer-aided design technology is beginning to be applied in the apparel industry. Garment CAD is based on interactive computer graphics (IGG). Adamietz et al [4], designers can develop, analyze, and modify his designs through computers, and ICG enables computers to Process data in the form of graphics or symbols. In 1972, the United States developed the first clothing CAD system, MARCON, and Gerber, the first company in the United States, introduced the clothing CAD system to the market, and was welcomed by clothing companies. The large-function system played an important role in alleviating the bottleneck of the industrialized large-scale garment production process—garment process design. Later, France, Japan, the United Kingdom, Spain, Switzerland and other countries have also launched similar systems.

Judging from the domestic situation, China's apparel CAD technology started late, but has developed rapidly. Vaughan et al [[5], at the beginning of the 1980s, while China's apparel industry introduced foreign advanced technologies, the scientific and technological community was also actively developing apparel CAD technology. In just ten years, it has basically occupied the domestic market, and has formed a situation comparable to foreign advanced technologies on several "International Garment Machinery Exhibitions." The application of apparel CAD in China has been rising continuously over the years. Santos et al [6], by the end of 1994, there were 200 sets of various clothing CAD systems across the country, and 500 by the end of 1998. According to incomplete statistics, currently there are about 4,700 sets of apparel CAD systems in use by apparel companies in the country, of which domestic CAD systems account for about 50%.

2 DEVELOPMENT TREND OF CLOTHING CAD SYSTEM

Computer-aided clothing industry production includes traditional modules such as computer-aided design CAD, computer-aided process planning CAPP, and computer-aided manufacturing CAM. With the development and application of network technology and intelligent technology, a new production mode with information flow as the core, from design and manufacturing, production management to marketing digitalization and integration, is becoming the development direction of the clothing industry. The use of computer-aided design and manufacturing (CAD / CAM) technology is one of the important contents of the technical transformation of the apparel industry. Judging from the development status of apparel CAD, it will have some new development trends in the future.

2.1 Information and Network Communication

With the rapid development of computer networks and telecommunications technologies, governments of all countries have formulated and implemented information highway plans, bringing human society into the information age. The clothing industry itself is an industry that is extremely sensitive to information. Mao et al [7], the fashion trends of clothing and the trends of the clothing market are vital information for clothing design and production. In today's fierce market competition, the timely acquisition, transmission and rapid processing of information are the basis for the survival and development of enterprises. Therefore, clothing information data, networking, and convenient remote communication technology are receiving more and more attention from clothing companies.

2.2 Multimedia Technology

Multimedia technology has extensive influence and direct application in the field of fashion design and processing. For example, the combination of image compression technology and optical disk storage technology in the multimedia field enables clothing and design information based on graphics and images to be stored in a computer in a digital form; a multimedia graphic database, image / graphic editing software, and information consulting. The development of software technology provides a theoretical basis and development environment and tools for the development and development of clothing information databases. The combination of multimedia technology and modern communication technology will bring the collection, dissemination and application of clothing information into a new era.

2.3 Three-dimensional Clothing CAD

At present, clothing CAD mostly stays in the two-dimensional field. Although many clothing CAD systems include technologies such as three-dimensional fitting, they are still in the exploration stage, and there is still a distance from practical requirements. From the current development direction of each CAD company, there is a lot of space for in-depth research in the three fields, but it is more difficult. But this is undoubtedly a major development direction of apparel CAD. If this technology can truly break through, it will bring revolution to the apparel industry and related fields. From graphic design to three-dimensional design, how to apply the latest technological achievements in interactive computer graphics and computational geometry to build a three-dimensional dynamic clothing model and solve the conversion of two-dimensional to three-dimensional and three-dimensional to two-dimensional in clothing design is the study of clothing CAD. One of the important topics.

3 DESIGN AND IMPLEMENTATION OF INTELLIGENT CLOTHING STYLE STRUCTURE CAD SYSTEM

The intelligent clothing style structure CAD system is based on the idea of an expert system. The styles provided by professional designers are stored in the database in digital form, and intelligent algorithms are provided, so there is no professional requirement for users. Users can freely call the components in the database and combine them to automatically generate clothing styles that users desire. The options include all aspects of clothing, such as clothing style, style, fabric, color, and pattern. If the user is not satisfied with the solution provided by the system, they can also make manual adjustments, such as changes in style, changes in profile, changes in components, movement and size modification, etc., until the ideal style is obtained, which can fully reflect the humanity. design concept.

3.1 System Interface Design and Implementation

In order to complete the whole process of designing a clothing style, this system includes two parts: a system module and a user module. The system module generally adds and modifies the clothing parts database; the user module is used for clothing design and consists of the following parts. Smart stitching of styles, adjustment of style details, overall adjustment of styles, filling of materials, and sets of sets of people. The specific process of a clothing design is shown in Figure 1. The main functions of the user module are as follows:

1) Smart style stitching: splicing various clothing parts into a complete garment, including two methods, automatic stitching and manual stitching. Automatic splicing is when the user selects the system to store the clothing parts of the complete clothing series that the user prefers to form a new style; manual splicing is when the user directly selects the appropriate parts in the parts library to replace the existing parts.

2) Adjustment of style details: After the user has completed the general design of the clothing, if he is not satisfied with the details of the clothing components, he can adjust the details of each component. At this stage, the system also provides two methods: the user directly edits the key

points or selects the style of the component to make the system automatically complete the movement of the key points to form different styles of clothing.

3) Overall style adjustment: The top and bottom loading can be adjusted. The top and bottom loading can be either the style designed by the user or the style stored by the system, and finally a set of reasonable matching top and bottom loading is formed.

4) Fabric filling and covering sets: The previous stages are designed with style lines. During the filling stage, users can fill different fabrics and use covering sets, which is more realistic and can help users to have a sense of the designed clothing. Goel et al [9],at the same time, the user provided a system database or a user database. The system database is provided by the system and contains clothing parts, clothing and tops made by professional clothing designers in advance. The user database data is created by the user. Interactive and completely transparent to the user.

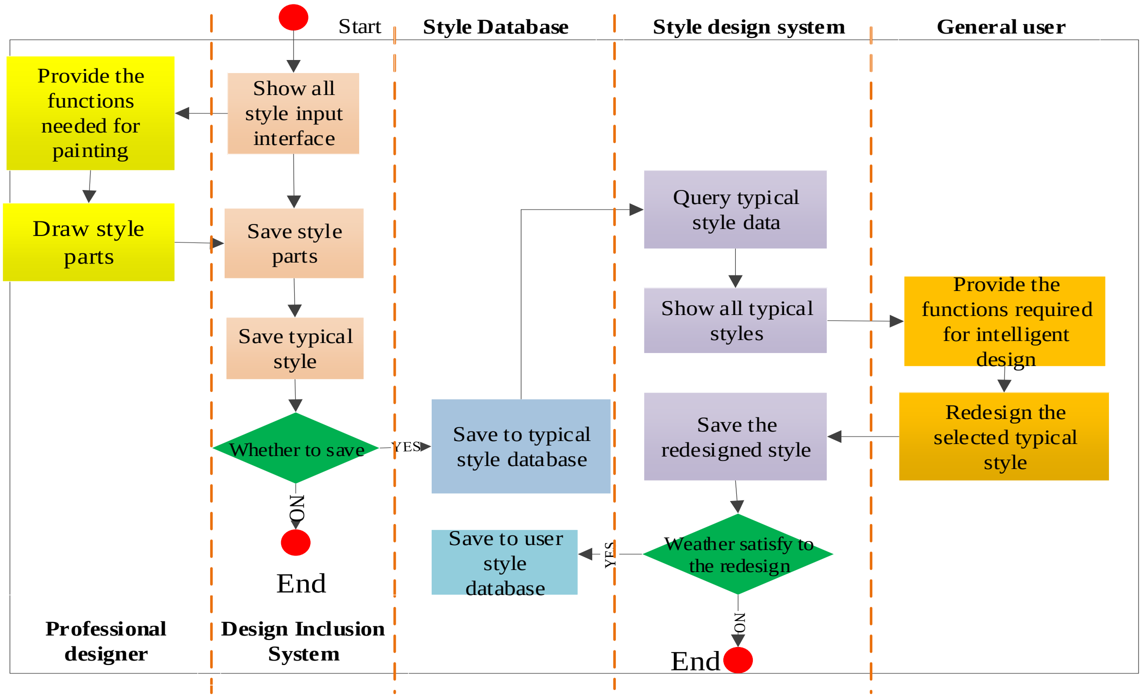

Figure 1: User module design process.

3.2 Interface Design Scheme Flowchart

The settings of each step are the same, they are divided into: 2 provincial roads, 3 divisions, 4 pockets, 5 accessories adjustment, but the interface design and operation functions made by the corresponding parts will be slightly different. "Original library" is the original input style library. There are only line styles. There are strict style definition points type, and can only save the front style, users should be cautioned when saving. "User library" is user-defined style library, which can save line style and color style to create a separate back style database. Flow chart of interface design scheme was shown in Figure 2.

4 DESIGN AND IMPLEMENTATION OF INTELLIGENT STITCHING MODULE FOR CLOTHING STYLES

In the field of clothing design, a garment can be broken down into relatively independent garment parts. For example, a coat is composed of clothing pieces, sleeves, provincial roads, pockets and zippers. For each part, the system first determines the feature points that best represent its shape, and then fits these feature points with several cubic B-splines to form a line drawing of the part.

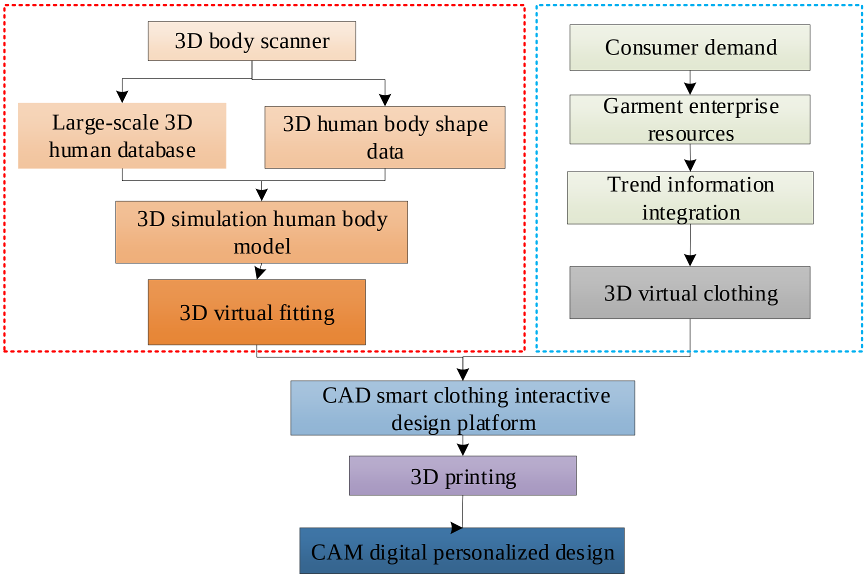

Figure 2: Flow chart of interface design scheme.

4.1 Garment Part Coding and Ceneration

Because of the wide variety of clothing styles, each clothing component also contains a variety of different style sub-categories. Wang et al [10], for example, collars can be divided into collars, lapels, stand-up collars, stand-up collars, hooded collars, etc., and each category is divided into several categories. In order to identify key points and lines in clothing parts, these points and lines must be coded to ensure that each key point of each part has a unique internal number. For example, the system defines key points and key line codes as shown in Figure 3. For more complex pieces or folds, more key points and key lines need to be defined.

These characteristic points and characteristic lines are defined. According to the knowledge of clothing design, adjusting these key points to different positions can form a series of clothing parts with different styles. For more special styles, it may be necessary to increase or decrease the number of key points, so the system reserves sufficient codes for these situations. For the generation of these components, the system module provided by this system can complete this task. Because the clothing style display software requires a large number of complete and original clothing styles as the basis, all data in the system database are completed by professional clothing designers according to this module and stored in the database. The system module provides drawing tools, desktop control tools, and parts saving tools. The user locates each key point on the standard platform provided by the system according to the above coding rules, and the system automatically generates corresponding parts based on these points and stores them in the system database. Each part is stored in 3 tables: part attribute table, part curve attribute table, and component node attribute table.

4.2 Splicing Principle

When the clothing style is automatically generated, the system extracts and draws the component control point data in the database. At this time, the splicing problem will occur at the joint of the components.

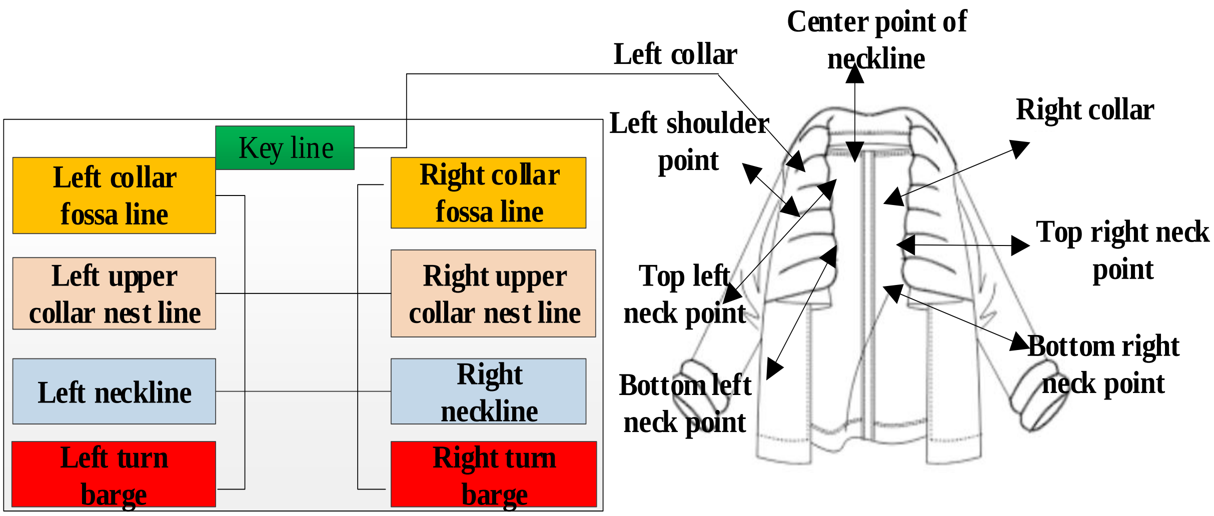

Figure 3: Key points and key line coding.

A set of parts designed on different styles is difficult to combine to achieve satisfactory results for the user without any changes (including position and size), because in this case, the overlapping or misalignment of two adjacent parts usually occurs. phenomenon. In order to improve work efficiency and reduce designer's repetitive and approximate labor, it is necessary to realize intelligent splicing of parts. According to the formal definition of parts, the system can combine different types of structural knowledge and graphic shape features to distinguish and respond to different splicing situations, so as to automatically solve the problem of splicing between parts.

To this end, some processing must be done on the parts before splicing. Set some key points for each part to identify the splicing interface with other parts. Different types of key points are marked with different numbers, and the key points on the adjacent two components that identify the same interface are in the same position. As shown in Figure 4.

(1) Splicing order

According to the stitching rules that appear in the formal description, the logical order of stitching must be quite clear, otherwise a very serious error will occur. For example, the suspender piece is equipped with a lapel, which is caused by the unknown logical order of the parts. The overall stitching sequence is to draw the sleeves first, then the collar, and finally the clothing pieces.

There are several important stitching rules that must be considered: no collar cannot fight collar, no sleeve cannot fight sleeves, shirt collar cannot fight coat pieces, coat sleeves can only fight coat pieces, shirt sleeves cannot fight coat pieces. As long as one of these conditions is not met, splicing cannot proceed. For example, the style parts searched from the database are coat pieces, coat sleeves and shirt collars. Because shirt collars and coat pieces cannot exist at the same time, these three parts cannot be combined into a single top. You must jump out and re-judge the next three parts Eligible. Therefore, we must introduce judgments on these conditions during the splicing process. The process is shown in Figure 4.

(2) Stitching algorithm

The transformation algorithms commonly used in stitching are mainly three types of translation, scaling, and rotation:

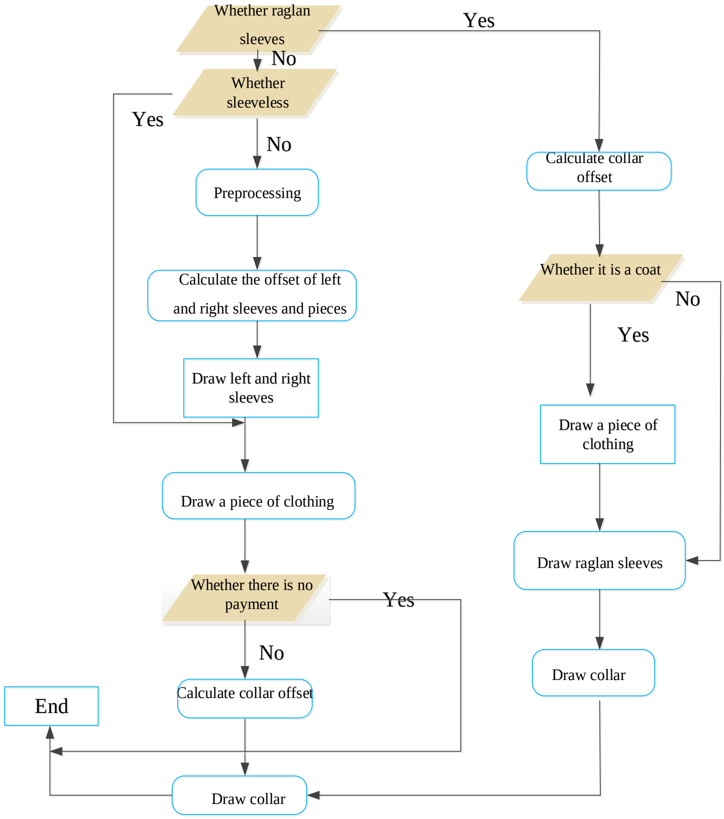

Figure 4: Flow chart of stitching sequence.

(A) Translation transformation

$$\begin{bmatrix} x' & y' & 1 \end{bmatrix} = \begin{bmatrix} x & y & 1 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ T^x & T^y & 1 \end{bmatrix} = \begin{bmatrix} x+T^x & y+T^y & 1 \end{bmatrix} \tag{1}$$

(B) Proportional transformation

$$\begin{bmatrix} x' & y' & 1 \end{bmatrix} = \begin{bmatrix} x & y & 1 \end{bmatrix} \begin{bmatrix} S^x & 0 & 0 \\ 0 & S^y & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} S^x x & S^y y & 1 \end{bmatrix} \tag{2}$$

(C) Rotation transformation

$$\begin{bmatrix} x' & y' & 1 \end{bmatrix} = \begin{bmatrix} x & y & 1 \end{bmatrix} \begin{bmatrix} \cos\theta & \sin\theta & 0 \\ -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} \cos\theta x - \sin\theta y & \sin\theta x + \cos\theta y & 1 \end{bmatrix} \tag{3}$$

4.3 Cloth Filling and Nesting Table

After finishing the above clothing style design, this system provides the cloth filling and ergonomic platform module for finer adjustment. Cloth filling is to fill the line clothing style with the cloth texture image provided by the system or imported by the user to make it rich in texture; the function of the set of people is to simulate the designed clothing to be worn on the person to achieve the effect of virtual fitting. These two sub-modules greatly facilitate users to judge whether the design meets the requirements.

This system provides several popular clothing cloth texture style images. At the same time, users can also edit them or import external images to fill clothing. The system's cloth filling is based on parts, which means that each part of a garment can be filled with a different cloth texture. Picture 8 right Picture shows the effect of clothing after filling the fabric and putting it on the platform. It can be seen from the Figure 5 that this module can basically meet the requirements of non-professional users to view the realistic effects of clothing. The effect map of this step can be stored in the user database and can be exported from the system in the form of .bmp bitmap.

During the sample clothing experiment, the selected human data was obtained by manual measurement. A total of 15 subjects were measured. Among them, the change in bust was used as the basic condition for selecting the test subject. The bust was changed from 80cm to 90cm, with 2cm as a jump. A total of 5 people, denoted as S1, S2, S3, S4, S5. The dimensions of the sample garment related to the human body are as follows in Table 1:

Variable name	Variable description	S1	S2	S3	S4	S5
SG	Height	154.7	158.5	161.3	164.3	166.8
XW	Bust	80	82	84	86	88
YW	Waist	63	67	70	73	70
TW	Hips	85	88	93	90	88

Table 1: Human-related dimensions.

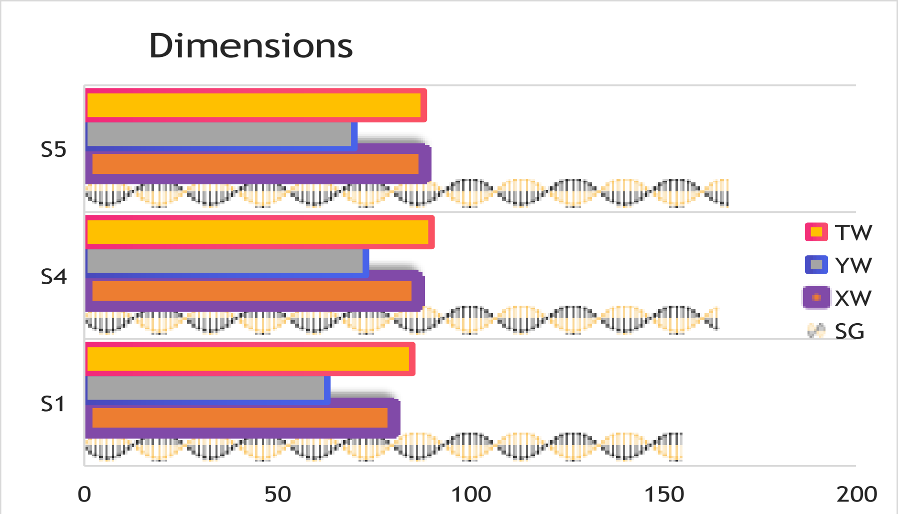

Figure 5: The human-related dimensions.

Analyze all variables of this template to learn the variables bust XW, garment bust (CYXW), garment waist (CYYW), ready-to-wear hip (CYTW), height (SG), waist (YC), which have the greatest influence on the template. These variables are grouped into two major categories by analyzing the variables. The first category: Variables, the second type: variables in the length direction. By changing these two types of variables, verify whether the template is running normally and whether the body is deformed. Among them, considering the rationality of the pattern design, during the experiment, XW and CYXW changed simultaneously and were consistent, and SG and YC changed simultaneously. The jump value of the variables in the girth direction is 4 cm, the jump value of the variable SG in the length direction is 5 cm, and the jump value of YC is 2.5 cm, which is a total of six changes. After changing the variables, the experimental results are shown in Figure 6, Figure 7, Table 2 and Table 3.

Variable	XW	YC	SG	CYXW	CYYW	CYTW
1	75	62	160	83	73	93
2	80	62	160	87	75	94
3	85	62	160	91	74	93
4	90	62	160	95	74	94
5	95	62	160	99	75	93

Table 2: Verification experiment results.

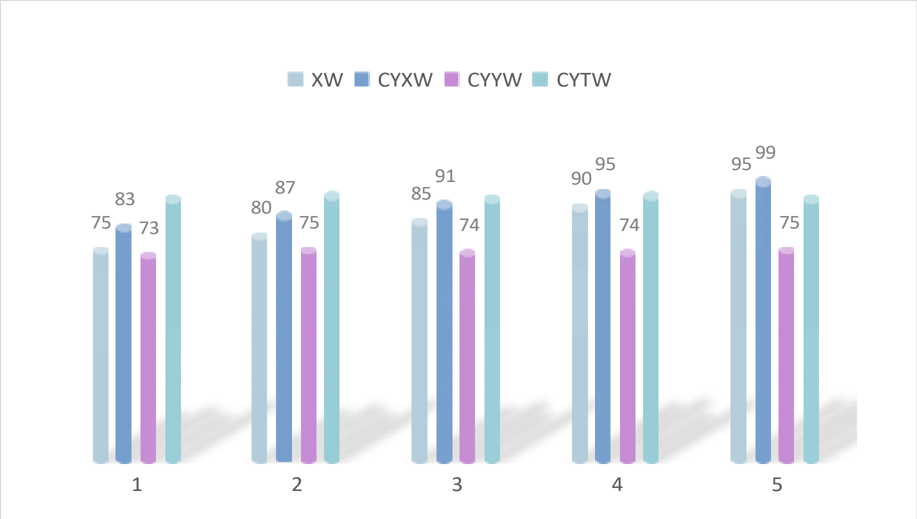

Figure 6: The verification experiment results.

Variable	XW	YC	SG	CYXW	CYYW	CYTW
1	75	55	160	83	66	84
2	80	57.5	162	90	70	88
3	85	60	163	94	74	92
4	90	62	165	98	78	94
5	95	63.5	167	102	82	96

Table 3: Verification experiment results of the two-body body module.

From the above experimental results, it can be known that when the experiment is performed, only changing the variable XW in the direction of the circumference has an influence on the entire template. When designing the pattern, the parts that have parameter relationships with this variable, such as collar width, chest width.

Figure 7: The verification experiment results of the two-body body module.

The width of these parts will change with the change of XW. Changing the variable SG in the length direction affects the size in the entire length direction, such as collar depth, armhole depth, waistline position, etc. Obvious deformation occurs, and when CYXW, CYYW, CYTW, YC is changed, it does not affect the size of other parts of the body. When all variables are changed, the body template can still operate normally without significant deformation.

5 CONCLUSIONS

Most of the existing clothing CAD software design modules are more mature and innovative in fabric design, but the style design module has weak functions, few innovations and practical advantages, but due to its immature development, the design module has not yet been developed. The determination of the framework model, on the other hand, illustrates the size of its development space. Based on this, this article proposes a component-based intelligent clothing style CAD system framework. In terms of design ideas, we must step out of the field of low-level design, explore how to combine the characteristics of clothing style design itself, and integrate professional knowledge into component design. Make the complicated clothing design process into a simple part splicing process. At the same time, the user is no longer operating on the underlying elements such as points and curves. Instead, it is a practical clothing part, allowing users to design from a global perspective instead of sticking to it. Due to the local characteristics, it is helpful to inspire users' creative inspiration, and provides a simple and easy-to-understand design platform for non-professional clothing style designers.

Lan Hu, https://orcid.org/0000-0002-4282-3115

REFERENCES

[1] Zhou, Y.; Zang, J.; Miao, Z.; Minshall, T.: Upgrading Pathways of Intelligent Manufacturing in China: Transitioning across Technological Paradigms, Engineering, 5(4), 2019, 691-701. https://doi.org/10.1016/j.eng.2019.07.016

[2] Mok, P.-Y.; Xu, J.; Wu Y.-Y.: Fashion design using evolutionary algorithms and fuzzy set theory–a case to realize skirt design customizations, Information systems for the fashion and

apparel industry, Woodhead Publishing, 2(1), 2016, 163-197. https://doi.org/10.1016/B978-0-08-100571-2.00009-9

[3] Lee, C.-H.; Chen, C.-H.; Amy, J.-C.: A structural service innovation approach for designing smart product service systems: Case study of smart beauty service, Advanced Engineering Informatics, 40(1), 2019, 154-167. https://doi.org/10.1016/j.aei.2019.04.006

[4] Adamietz, R.; Tim, G.; Pablo, M.; Andrew, J.; Richard, B.; Christian, S.: Reconfigurable and transportable container-integrated production system, Robotics and Computer-Integrated Manufacturing, 5(3), 2018, 1-20. https://doi.org/10.1016/j.rcim.2018.02.008

[5] Vaughan, N.; Bodgan, G.; Venketesh, N.-D.: An overview of self-adaptive technologies within virtual reality training, Computer Science Review, 22(1), 2016, 65-87. https://doi.org/10.1016/j.cosrev.2016.09.001

[6] Santos, P.; Campilho, R.; Silva, F.-J.-G.: Design of a novel equipment for automated clothing manufacturing, Procedia Manufacturing, 17(1), 2018, 766-773. https://doi.org/10.1016/j.promfg.2018.10.127

[7] Mao, A.; Luo, J.; Li Y.: Xiaonan Luo X.; Wang, R.: A multi-disciplinary strategy for computer-aided clothing thermal engineering design, Computer-Aided Design, 43(12), 2011, 1854-1869. https://doi.org/10.1016/j.cad.2011.06.009

[8] Morais, C.; Gianni, M.: Customized wardrobe: clothing according to user, Procedia Manufacturing,2(3), 2015, 5814-5821. https://doi.org/10.1016/j.promfg.2015.07.833

[9] Goel, A.-K.; Swaroop, V.; Bryan, W.; Michael, H.: Cognitive, collaborative, conceptual and creative—four characteristics of the next generation of knowledge-based CAD systems: a study in biologically inspired design, Computer-Aided Design, 44(10), 2012, 879-900. https://doi.org/10.1016/j.cad.2011.03.010

[10] Wang, R.; Xiangyu Wang, X.; Kim, M.-J.: Motivated learning agent model for distributed collaborative systems, Expert Systems with Applications, 38(2), 2011, 1079-1088. https://doi.org/10.1016/j.eswa.2010.05.003