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Research Article

Application and Development of Computer-Aided Design Methods in Clothing Design under the Environment of Internet of Things

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With the rapid development of Internet technology, its computer-assisted functions are also rapidly improving and the changes in computer functions have brought great convenience to all the aspects of life. In the clothing industry, the application of computer-aided technology and the production of sample clothing and the rendering of clothing have been introduced. This method greatly shortens the cycle of making and designing clothes and also greatly reduces the workload of the staff. The main content of this article is to explore the influence of the application of CAD on clothing design. Starting from the actual needs of digitally designed clothing, the formation model of clothing and the basis of digital application are derived. In this article, computer-aided technique is used as a modeling development tool and its related functions are introduced through methods such as multideformation modeling and NURBS surface modeling. According to the functional characteristics of the computer-aided dye applicator, it is concluded that the dyeing effect of the model is also diverse, and then the virtual display effect of the digital three-dimensional model of the clothing is obtained. Through the digital design, the clothing design can not only meet the functional requirements but its performance also meets the reliability, stability, and safety. The experimental results show that with the increase of W, the area of the two-dimensional unfolding film gradually increases and the amplitude becomes smaller and finally stabilizes at 0.1263.

1. Introduction

In recent years, with the rise and development of computer technology, especially the Internet technology, the clothing industry has gradually brought computers into the clothing production and other links because of the actual needs, such as the pursuit of efficiency and the need for the realization of new technology. China is the world's largest textile producer and exporter, and the textile and garment industry is the pillar industry of China's export earnings [1–3]. After China's accession to the WTO, the biggest challenge faced by the textile and garment industry is innovation, ability, and brand competition. According to the existing research, the value of innovation and brand is increasing in world trade. The profit space of the world is shrinking year by year only relying on labor resources. Only by improving the quality and innovation ability, enhancing the development and

research ability, and speeding up the information construction can the competitiveness of Chinese textile and garment enterprises be comprehensively improved [4–6]. Therefore, in the information age, clothing, like other industries, is undergoing profound reform, from traditional paper and pen drawing to computer-aided design with various software packages, which requires not only the combination of abstract art and practical technology but also the interaction of rational technical conditions and emotional sensibility, which is the future trend of clothing [7]. The characteristic of CAD is to realize the development and innovation of fashion design based on science and technology and to extend its design concept widely, so as to drive its development process [8–10]. This is the development value of CAD for fashion design and is also an important embodiment of the continuous progress of design concepts driven by the development of science and technology

[11, 12]. In this way, we can break through the shackles of traditional fashion design and achieve the ultimate goal of innovative development of fashion design [13–15]. The continuous development and progress of the times put forward new requirements for the application of science and technology, and the position of computer-aided design in fashion design and development is also crucial, which is the key to promote the scientific development of fashion design thinking and concept formation [16]. This is also the main embodiment of the concept of scientificity and integration and one of the advantages of its application [17, 18].

Taking the typical Tibetan clothing as an example, Guo Chen proposed a virtual reality interactive teaching mode for clothing design education. These processes include the use of 2D clothing CAD software to display traditional clothing structures, the use of virtual reality technology to make clothing models, and the use of a unity game development platform for interaction. This virtual reality interactive teaching method expands the traditional clothing design teaching method and traditional clothing design development research [19]. Webster and Ed discussed how computer-aided drawing and computer-aided engineering programs can be used to simplify the design of television systems and facilities. The hardware design, basic system composition, typical CAD workstation software, and system design application of the system are discussed. This paper summarizes the design of facility building and TV system, including whether to use CAD/CAE software or not. Finally, taking the overall design of the mobile remote production vehicle as an example, the application of CAD/CAE is mainly introduced [20]. It can be found that their research pays more attention to the scale of garment production and the improvement of efficiency, but there is no improvement in design. Therefore, it is meaningful to audit fashion design based on computer-aided design.

This paper follows the development trend of the industry and applies modern information technology to the digital forming technology of garment three-dimensional modeling earlier in China, so as to make the research level of this direction keep pace with the advanced level of foreign countries. Based on the theory of garment engineering and modern information technology, the three-dimensional digital stereo forming technology and the concept of computer graphics are effectively combined, which embodies the innovation of this paper: (1) pay attention to the technical innovation of digital design relying on the theory of technology; (2) innovation of garment production method: pay attention to the transformation of traditional garment design method by modern digital technology.

2. Proposed Method

2.1. Application of CAD Technology in Garment Design

2.1.1. Application of Clothing Style. Fashion designers can use the rich and colorful brush library in the computer painting function, such as Photoshop to create an image of the human body model and appropriate clothing styles, and after designing the latest styles, they can directly select the best models and actions from the previous human body model database or design more appropriate styles based on the body shape of models. When designing clothing styles, designers can use "undo, restore, eraser" and other function keys to make style modification more flexible. In addition, the designer can make full use of the layer function to modify some patterns of the clothing and all the design schemes can be stored in the computer, without the need for manual redrawing. Scanners, hand-painted boards, and other professional tools can also put the hand-painted lines highlighting the designer's unique personal style into the computer, so the use of computer-aided design means can perfectly integrate art and technology. For the texture of clothing, it can be polished on editing software such as PS to achieve elegant, comfortable, and other effects.

2.1.2. Application of Color and Fabric Filling. Painting in a certain area of clothing is a very time-consuming and labor-consuming work, but the use of computer-aided design technology can easily solve this problem. It can not only transform between color block and color but also complete the problem of "traditional hand painting rework" with a click of the mouse. This efficient way of work is incomparable to hand painting. Generally speaking, when designers draw clothes by hand, they often need to use a variety of tools, such as watercolor pen, brush, marker pen, color lead, and drawing board. These tools are not only very expensive but also consume surprisingly fast. But for Photoshop and Auto-CAD, it is just a problem of a scanner or a sketchpad. It can change the color, flow, shape, transparency, and so on of the brush anytime and anywhere. If the designer wants to borrow a pattern on a shaped garment, the hand painter needs to do manual drawing work, but the scanner in the computer drawing software can copy it to the computer with one key. In the later modification process, the designer can adjust the saturation, color temperature, contrast, etc. according to the actual situation, so that the color of the garment becomes more gorgeous and dazzling. Due to the development of modern science and technology, there is almost no color difference between the color of electronic equipment and the color in real design, so there is no need to worry too much about the color difference.

2.1.3. The Application of Computer-Aided Clothing Design. The intelligent drawing tools and new dynamic guides provided by CORELDRAW software can fully reduce the difficulty of user manipulation, allow users to create the size and position of objects more easily and accurately, reduce click steps, and save design time. Take a casual women's top as an example. In terms of style design, designers can use CORELDRAW software to open the pattern library of women's wear and select the most appropriate pattern to match, so as to complete the basic design drawings. After that, the designer can import more styles of collar, cuffs, and other combinations, until the selection of excellent style drawings, and complete the details of the design. Then, in the process of clothing fabric design, the designer can import the best pattern in the fabric library with the pattern filling tool

provided by the software and determine the appropriate proportion of fabric size, inclination, and tiling. The last part is the material simulation, which uses the filter and layer functions of the drawing software to show the performance effect of the two-dimensional fabric image on the clothing style and then simulate a variety of fine textures.

2.2. Computer-Aided Digital Clothing Modeling Method

2.2.1. Computer-Aided Technique. 3D modeling, one of the computer-aided technologies, is a modeling software package based on Win NT or Win 98 platform. It is one of the most widely used 3D modeling software on personal PCs. With the continuous introduction of new versions, the versions after 3.0 have significantly improved in terms of workflow mode, custom interface, renderer, and modeling technology, consolidating the position of 3 ds Max on personal PCs. 3D modeling in fashion design can clearly and stereoscopically display the details of clothing, and the regulation of details is very delicate, which is conducive to the style innovation in fashion design.

There are two main methods for 3 ds Max modeling, a geometric model-based method and an image-based rendering method. Clothing modeling mainly adopts methods based on geometric models. When carrying out clothing digital modeling, we must follow a principle, under the premise of ensuring the visual effect of the clothing three-dimensional modeling, we try to use a simpler model and try to use a parametric construction method to draw. At the same time, in the process of creating a clothing model, the model must first be segmented, which is conducive to operation or observation in the virtual reality system.

The establishment of the clothing model will directly affect the quality of the entire virtual reality system. Compared with two-dimensional modeling systems, three-dimensional digital modeling can more completely represent the geometric three-dimensional modeling of objects in the computer, which provides a certain foundation for the expression of virtual clothing. 3D digital modeling technology is the core technology of 3D digitilization. There are many 3D modeling methods, including surface modeling, solid modeling, parameter modeling, feature modeling, and component modeling, mainly polygon modeling, sliced NURBS surface modeling, and patch modeling.

2.2.2. Three-Dimensional Modeling of Clothing. Generally speaking, building a model can be done by several methods, but there are advantages and disadvantages. The modeling of clothing belongs to complex hybrid modeling, which designs the developable surface of clothing from the perspective of set. According to different parts of the human body, the clothing worn on the human body will change according to the dynamic changes of the human body. Among them, the different effects on human body parts are divided into dynamic parts and static parts. For the dynamic part of human body, the NURBS surface modeling method based on a slice is used; in this way, the model can take into account the stretching of the human body and the deformation of the

human body, thus dynamically adjusting the model size; for the static part, polygon modeling and patch modeling method can be used to describe the qualitative part more quickly. Therefore, aiming at the digital modeling mode of human body clothing, this section proposes to use traditional CAD software, use the VR system and 3 ds Max to develop interactive object model, and use a hybrid modeling mode based on polygon modeling, patch modeling, and NURBS surface modeling to realize the visualization of mixed modeling of clothing.

The clothing model is obtained by the method of three-dimensional modeling, and the means of three-dimensional modeling will inevitably affect the operability of 3D printing clothing. The modeling visualization effects of polygon modeling are shown in Figure 1, patch modeling are shown in Figure 2, and NURBS modeling are shown in Figure 3.

The basic idea of garment 3D modeling is to form the garment basic body with polygon modeling and perform local processing with patch modeling and NURBS modeling. Comprehensive modeling can reduce working time and improve modeling efficiency. 3D printing is a kind of rapid prototyping technology, also known as additive manufacturing. It is a technology based on digital model files, using adhesive materials such as powdered metal or plastic to construct objects by printing layer by layer. 3D modeling can provide 3D printing models.

3. Experiments

In this paper, 3D modeling software is used to design clothing, the hardware platform is Windows, and the data processing is analyzed by SPSS. The details are as follows.

3.1. Database Design

3.1.1. Database Entity E-R Diagram

(1) User Information. It is mainly used to store user's characteristic information, such as age, occupation, and education background. The user information attribute diagram is shown in Figure 4.

(2) Human Characteristics Information Data. It is mainly used to store human body feature information, including human height, skin, gender, head, body part, leg, and other human body feature information. The attribute map of human body's characteristic information is shown in Figure 5.

(3) Clothing Category Information. It mainly includes clothing category information, such as coat, vest, and other information. The Category attribute diagram of clothing is shown in Figure 6.

(4) Style Information. Style information table is mainly used to store the detailed information of clothing style, such as style, collar type, pocket, and board type. Its structure is shown in Table 1.
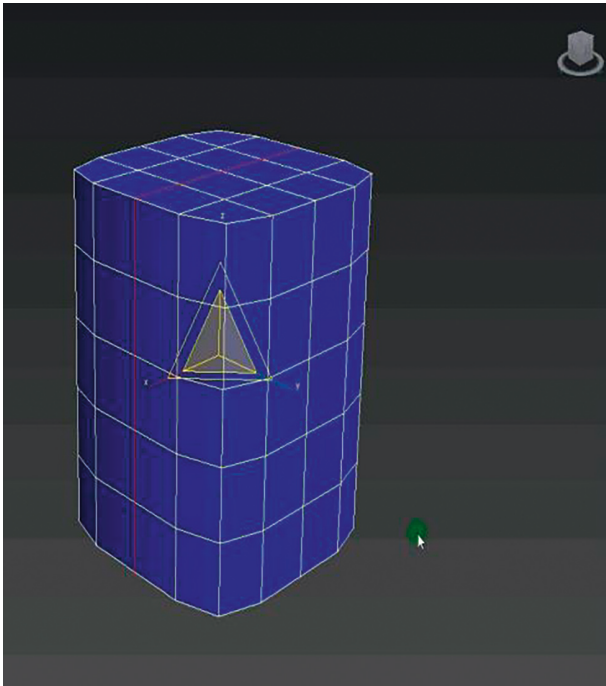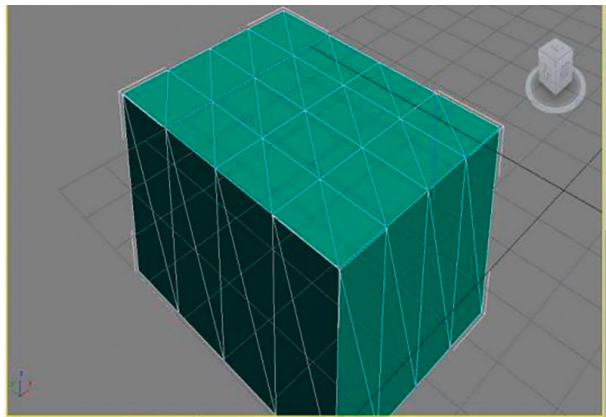
FIGURE 1: Polygon modeling.
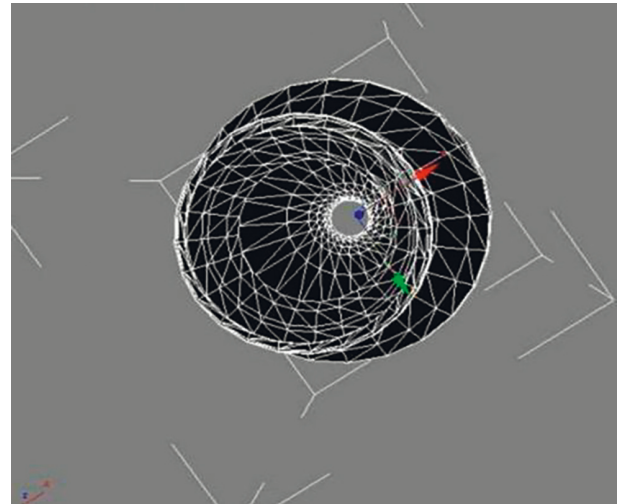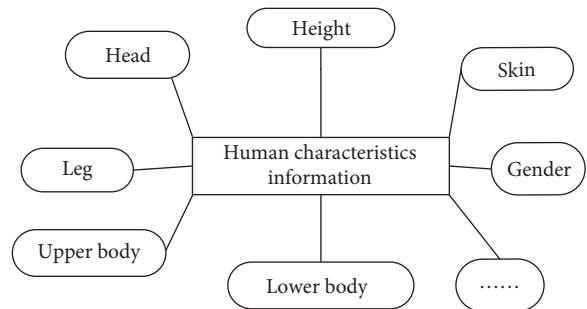

FIGURE 2: Patch modeling.

3.2. Software Testing

3.2.1. Test Method. Black-box testing focuses on the external structure of the program, regardless of the internal logical structure, and mainly tests the software interface and software functions. For each subfunction of the black-box test system, we input the corresponding test case on the website page to test each function, select the principle of test case, and design the test case according to the parameters that the user needs to input on the page.

3.2.2. Test Items

(1) Performance Test. Its purpose is to test the overall performance of the integrated system.

FIGURE 3: NURBS modeling.

FIGURE 4: User information attribute.

FIGURE 5: User-related data.

Test content: after integrating each module into the framework, we run the system and test the overall operation performance of the system.

(2) Function Test. Its purpose is to confirm the correct execution of each functional module of the system.

Test content: character modeling test and clothing design test are performed.

4. Discussion

4.1. Character Modeling. Enter software and create a new interface named "women's upper body modeling" file, with suffix .Max, to carry out women's upper body polygon
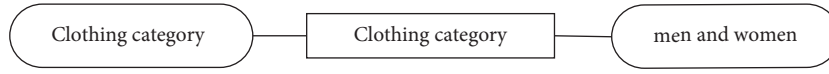
FIGURE 6: Clothing category attribute.

TABLE 1: Style information.

Field name	Data type and length	Allow space
StyleID	Int	No
StyleNO	Varchar (20)	No
CategoryID	Int	No
StyleType	Varchar (20)	No
Collar	Varchar (20)	No
Sleeve	Varchar (20)	No
Pocket	Varchar (20)	No
Button	Varchar (20)	No
Slit	Varchar (20)	No
Plate	Varchar (20)	No
StyleNote	Nvarchar (200)	Yes

modeling. Open a simulation scene of the object's female body, create a plane object, and display its front view as shown in Figure 7.

Select the white part of the plane in the figure, and right-click and select the "Edit polygon" option to turn it into an editable poly object. In the geometry classification menu, select the composite object, pick up the related ontology, and adjust and edit the polygon point to draw in the side view and front view. First, divide the plane object into 6 pieces vertically and 5 pieces horizontally, and move the poly point and the connected plane to move in three dimensions. In the drawing process, switch the front view and side view to ensure that the contour line cannot cross the body; finally, the ideal body shape of the female body wrapped in left anterior film is obtained. Considering the elasticity of the human body in motion, a certain degree of elasticity on the positive and negative sides is added to the built model, so that the model fits the human body better.

The function test of the character modeling part is shown in Table 2.

4.2. Clothing Modeling

4.2.1. Upper Garment Modeling.
In the process of clothing modeling, we first use polygon patch modeling method to define the boundary of clothing, construct a model similar to the shape of the object clothing, and then use the NURBS surface modeling method to process the deformation as shown in Figure 8.

Finally, according to the characteristics of the object female body and the requirements of the object fashion design, taking the above principles into account, the basic model of the upper body object female clothing frame editing view is shown in Figure 9.

4.2.2. Change of the Garment Area.
The line chart of the change of the two-dimensional garment area with the increase of W is shown in Figure 10.
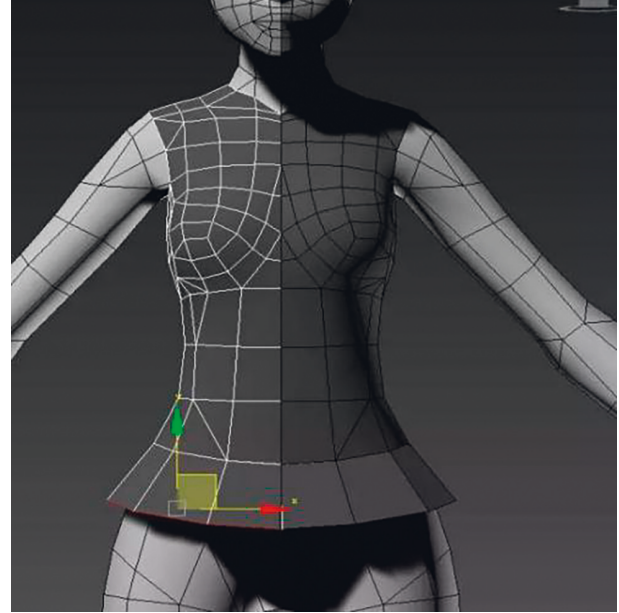

FIGURE 7: Plane object based on polygon modeling.

With the increase of W, the area of two-dimensional unfolded garment increased gradually and the range became smaller and smaller and finally tended to stabilize at 0.1263. As for the area of three-dimensional clothing, because the area of three-dimensional clothing is the sum of small triangular patches, the number and size of small triangular patches have been determined when generating three-dimensional clothing, so its value is unchanged.

4.3. Virtual Display Renderings.
The upper body and the lower body of the object women's clothing are modeled separately. The upper body modeling mainly uses the polygon modeling method of the function module covering the object. The method of polygon patch modeling and NURBS surface modeling is mainly used to draw wire frame for the lower skirt. The upper and lower modeling clothing pieces are sewn to get the virtual display effect of the object women's clothing. By means of conduction, the existing pattern of clothing fabric is attached to the modeled clothing block and the design scheme of the object women's clothing is shown in Figure 11. Although there are some errors in the transmission process, it is also an inevitable error in the design. It can be adjusted by hand painting later.

In the process of stitching the front and back pieces, there will be the situation that the combination position of the front and back pieces does not match, which shows that there will be position error in the drawing process. Because the subject is manual drawing, the error of the geometric

TABLE 2: Test table of character modeling part.

| Test title	Character modeling function test	
Test purpose	Test whether the character modeling function can operate normally	
Test object	General user	
Test name	Test steps	Test results
Character creation	Input parameters for persona modeling, view operation results, and generate persona model	The results are correct
Head portrait selection	Select the person's head image, select the hair style, and view the operation results	The results are correct
Face adjustment	Adjust the face of the character model slightly	Testing the facial function of the character model can accurately adjust to the target value
Persona save	Test to save the generated character model	The generated persona model is saved without exception
Conclusion	After the test, the expected effect is achieved and the operation is normal	
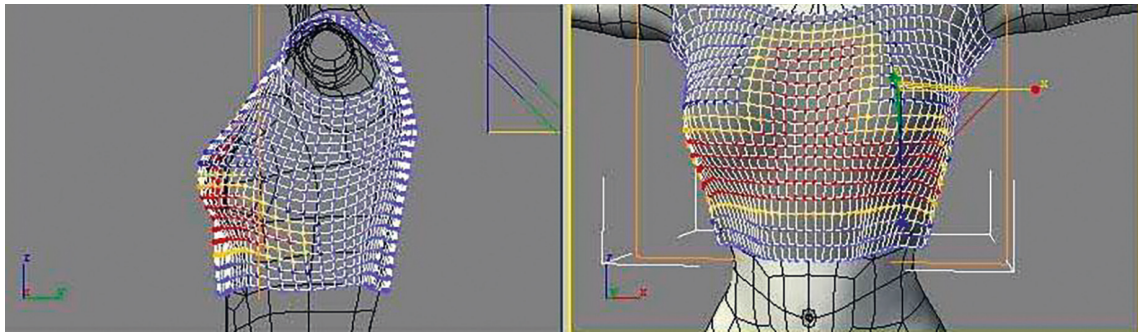
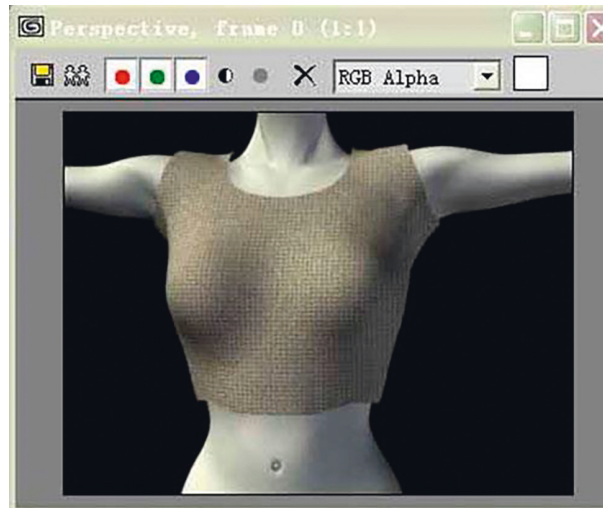FIGURE 8: Converting object clothing to editable poly.

FIGURE 9: Object dress model in wire frame edit view.

model caused by manual is inevitable, which affects the accuracy of the clothing model. Due to the lack of molding materials and equipment and other subjective reasons, the subject did not transform the virtual display effect map into the final solid model but only realized the parametric modification and innovative design of the model. However, with the progress of science and technology, after the model

parameters are set, the production of entities will be simpler. And, the parameters can be optimized for the existing model.

In order to properly increase the reality of the object's three-dimensional clothing, based on the functional characteristics of the 3 ds Max dye applicator, the dye effect of the model is varied, including the lighting, clothing material, and pattern forming effect. For the beauty of the clothing model,
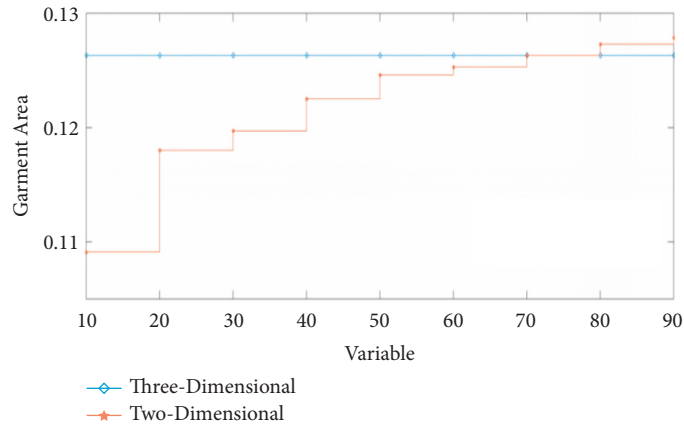
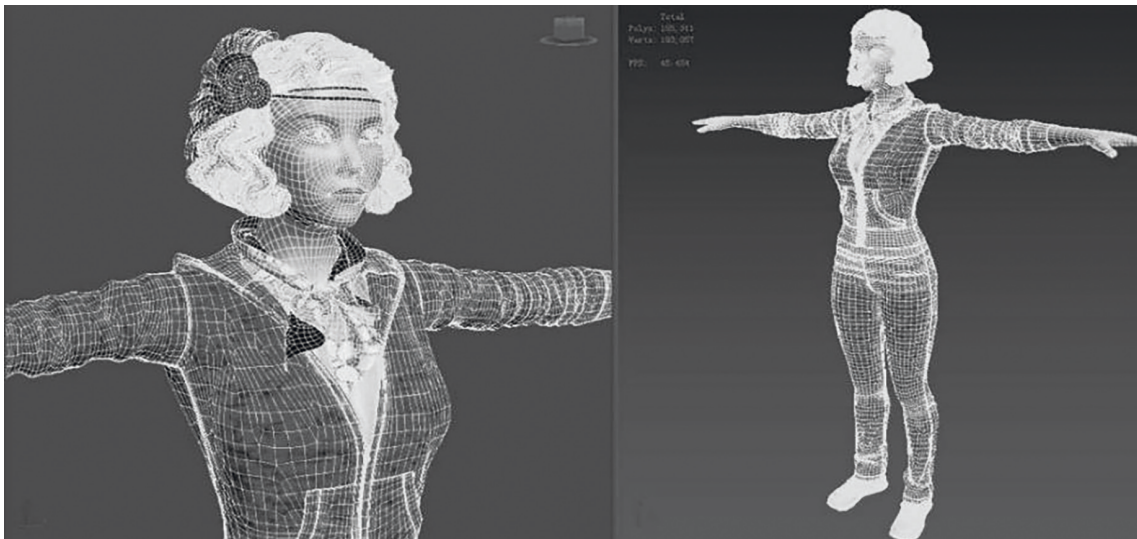Figure 10: 3-D and 2-D unfolded area line chart.

Figure 11: Design scheme of object women's clothing.

the virtual display effect of the digital three-dimensional clothing model of women's clothing is shown in Figure 12.

The test table of some functions of clothing design is shown in Table 3.

Through the test of the above system, it shows that the virtual system of clothing design meets the functional requirements, with reliability, stability, and safety, and meets the design requirements.

Figure 12: Virtual display effect of the female digital clothing model.

Table 3: Relevant function test table of clothing design part.

Test title	System test of clothing design	
Test purpose	Test whether the relevant functions of clothing design can operate normally	
Test object	General user, administrator	
Test name	Test steps	Test results
Garment cutting	In the clothing cutting part, key points can be set correctly, clothing pieces can be cut correctly, and operation results can be viewed	All operations can be completed normally and the results are correct
Garment splicing	The garment splicing part can move the garment piece correctly, arrange the garment piece, and check the operation results	All operations can be completed normally and the results are correct
Clothing preservation	Users can save, modify, delete, and share the finished garment items and view the operation results	All operations can be completed normally and the results are correct
Conclusion	The test results meet the expected results, and the module functions normally	

5. Conclusions

Relying on digital 3D design is an important difficulty in the field of manufacturing research. Using this technology to turn designers' related inspirations into reality is a technological innovation based on the combination of digital model design and computer graphics. The combination of digital technology and clothing design is based on the research of a number of key core technologies, including digital human body modeling and computer-aided body measurement, as well as clothing design research. As for the auxiliary system of fashion design, this paper makes use of 3D modeling, which not only strengthens the innovation but also strengthens the artistic sense of fashion design, making it more fashionable and more in line with the needs of the public.

This article first introduces the relevant computer-assisted human body technology theory, and then, based on modern digital technology, it expounds the basic concepts and content methods of the technology theory. This method uses digital clothing design that relies on mathematical foundations and ergonomics. On the basis of theoretical knowledge, combined with the editing of 3D digital model technology and computer graphics, we prepare for the abovementioned practical steps.

This article mainly describes the digital practice process of computer-aided clothing design, using digital design tools

to introduce computer-aided digital technology processing into clothing design, including body measurement, design modeling, three-dimensional modeling, and physical modeling. The overall process of proportion design and so on, correspondingly produced corresponding three-dimensional clothing effects and physical models.

Data Availability

No data were used to support this study.

Conflicts of Interest

The author declares no conflicts of interest.

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