Textile & Leather Review

ISSN 2623-6281| www.tlr-journal.com | 10.31881/TLR

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How to cite: Ouyang A. Application of 3D Human Body Measurement Technology in Cheongsam Sample Structure Design. Textile & Leather Review. 2026; 9:4877-4899. https://doi.org/10.31881/TLR.2026.4877

How to link: https://doi.org/10.31881/TLR.2026.4877

Published: 27 April 2026

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Application of 3D Human Body Measurement Technology in Cheongsam Sample Structure Design

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Article

https://doi.org/10.31881/TLR.2026.4877

Published 27 April 2026

ABSTRACT

The advancement of science and technology is causing significant transformations in the Qipao business. The technology of 3D measurement of the human body, automatic generation of the cheongsam model, and garment CAD has been developed rapidly. Industrial robots can analyse the structure and parameters of clothing based on the three-dimensional dimensions of the human body. The design of CAD involves selecting the proper geometry according to the specified parameters. Through the transformation of control parameters, it can quickly and conveniently generate a variety of graphics. On this basis, a set of garment template parametric association model based on 3D imaging technology is established, and this pattern is deeply discussed. The application of CAD helps improve production efficiency. In the production process, CAD technology can promote new development, improve product quality, reduce production costs, and thus greatly enhance the user's rapid response to design, production, and market, thereby strengthening the company's brand and brand strength. This research briefly expounds on the development process of the Chinese cheongsam from one side, and on the basis of consulting related materials, it further explores the development condition of the Chinese flag uniform and its reference system at present.

KEYWORDS

industrial robot, 3D measurement, CAD calculated, cheongsam design, model structure

INTRODUCTION

Cheongsam is one of the most typical garments in China. In modern cultures, ethnic cultural consumption is becoming more widespread. Three societal changes have made it more common today than it was in the past. The primary issue is the growing importance of symbolic and cultural consumption in the lives of everyday people [1]. This affects a large percentage of customers in developing nations and also those who reside in economically developed ones. Another trend is the movement in culture to globalisation, ethnic diversity, and cultural omnivorism [2]. Therefore, a deeper discussion of Qipao's organisational architecture and its integration with automated model creation is a trend for the near future. A parametric structural mapping program is developed based on this basis, wherein the appearance of the collar and cuffs is statically evaluated, the structure of the optimal solution is determined by comparing the structure of four different sets of garments according to subjective assessment and evaluation performed in four different ways, selecting ten professionals for each of the four sets of clothing [3]. People's interest is drawn to the delicate and uncomplicated nature of velvet flower crafts, which are a non-heritage traditional culture that is reviving. Considering that clothing is a key medium for the communication of fashion aesthetics, the Nanjing velvet flower is currently used as a distinctive craft on clothing by contemporary fashion ideals theory, fusing the blossom with contemporary design features [4].

Apparel CAD is a novel high-tech product that integrates network connectivity, database management, graphic design, and other expertise. The use of computers, with its high speed and accuracy, could considerably reduce labour costs for workers and increase productivity in manufacturing, freeing up people from labour-intensive manual tasks to engage in more creative work. The fashion industry in particular is trending toward multi-variety, limited batch, brief cycle, superior improvement, and the use of CAD to increase manufacturing efficiency. CAD technology can contribute to the manufacturing process by encouraging new product creation, raising product quality, cutting costs, and improving user responsiveness to design, production, and market demands. All of these benefits can help build a company's reputation and boost its brand strength [5,6].

3D anthropometric technology uses body scanners to collect all sorts of spatial information about the human body by measuring body features that are otherwise difficult to access with conventional measurements. Such features include the usual manual measurements, including waistband and bust, as well as different inflated or dynamic qualities, including curvature and posture [7]. This data is later input into garment CAD systems so that a designer can use the body shapes of selected users to create pattern templates. Accuracy at this stage is imperative regarding cheongsam design because the cheongsam is a body-conforming silhouette [8]. Minor errors in fit, such as shoulder slope or chest radius, have much more significance in the final fit than in more relaxed garments. As modelled data is website 3D-based, the accuracy of 3D anthropomorphic data ensures the accuracy of the cheongsam sample making.

To investigate the use of 3D human body size measuring technology in the structural design of cheongsam samples. The research demonstrates how anthropometric data derived from scanning can be combined with the CAD algorithms for the design of garments to achieve more accurate patterns [9]. The research investigates the correlation between body feature parameters of the customers, such as neck opening, with and without sleeve cap, waist shaping, and the structure of the neck lines, sleeve hills, and waist shaping of a cheongsam. The research employed regression analysis and comparative models to determine an ideal design framework depending on body type [10]. The process of integration in the design of cheongsam to improve aesthetics, comfort, and production efficiency, the research results can provide new direction in both the academic world and in realistic progression into intelligent garment manufacturing.

The merging of 3D anthropometric data and digital garment design cannot only improve pattern accuracy but can also support intelligent automation for advanced fashion production. Contextually, when garments are translated into digital files, complex body measurements transform into digital models that designers use for simulating garment fit, identifying and modifying structural elements in real-time, and reducing the physical prototype cycle [11]. This is significant for garments such as the cheongsam, which can correctly align with body contours, and ultimately enables customisation on scale. It can make traditional aesthetics relevant again in a contemporary form of mass production, and the merging of cultural heritage with digital precision is a big step forward in apparel technology. It also demonstrates a shift toward data-informed, user-centred design practices in clothing and textiles.

The clothing structure model, composed of points and lines, can be used to design the parameters of the drawing process. Can effectively improve the production of clothing model effects, thus reducing the sample production cycle.

Research Questions

1. How can 3D anthropometric data improve the precision and customisation of Cheongsam garment structures compared to traditional manual measurement methods?
2. What are the key limitations of existing 3D human body scanning systems in accurately capturing dynamic body dimensions for garment CAD modelling?
3. In what ways can industrial robots be effectively employed in the Cheongsam design process to

streamline pattern generation and enhance production quality?

4. What role does constraint-based, size-driven design play in the structural optimisation of Cheongsam models within CAD environments?
5. How do different shoulder, neck, chest, waist, and hip characteristics affect the structure and aesthetics of CAD-based Cheongsam templates?

Problem Statements

Despite advancements in digital fashion design, the automatic generation of clothing samples, particularly for traditional garments like the cheongsam (qipao), faces notable challenges. Earlier systems were either based on very basic design principles or catered only to specific, limited styles, rather than encompassing the diversity inherent in cheongsam fashion. Traditional methods of cheongsam design relied heavily on flat-pattern techniques and manual measurements, which resulted in poor fitting, limited adaptability to individual body types, and time-consuming sample generation. Previous technologies for plate-making operated through human-computer interaction, where the screen replaced paper and the mouse replaced the pen. While these methods improvedproductivity to some extent, they did not fully leverage the potential of digital automation. These interactive approaches remained largely manual and offered only a low level of automation, failing to enhance professional precision or efficiency significantly.

With the growing demand for custom-fit garments that reflect unique body shapes and preferences, traditional methods have proven inadequate. However, integrating 3D anthropometric scanning with constraint-driven CAD modelling and robotic automation presents a promising solution. This research uses a data-driven approach to pattern generation, allowing for parametric adjustments tailored to various body regions. Unlike static templates used in previous research, this method enhances structural adaptability and fit accuracy. Moreover, automated printing and pattern generation systems significantly reduce the complexity of sample creation. What previously required hundreds of manual steps can now be executed through minimal input and localised corrections. By establishing a scientifically classified pattern system and optimising design parameters, the proposed framework improves production speed, accuracy, and customisation in cheongsam manufacturing, fulfilling both traditional aesthetic values and modern functional demands.

Historical Development and Industrial Production of Qipao

Cheongsam is a type of clothing that evolved, primarily worn by Manchu women during the Qing Dynasty. The Manchu people, also known as "Qiren," wore clothing called "Qipao". The dress of the flag people was generally set, but with the changing times, the clothes evolved, and only women would wear "Qipao." The early cheongsam had a low, round collar, narrow sleeves, and an A-shaped skirt. By the mid-20th century, the width of the cheongsam exceeded 30 centimetres, and sleeves increased. By the late Qing Dynasty, a large garment lapel similar to a silver coin was introduced, maintaining a straight and wide appearance [12,13].

Following almost three centuries of growth, the cheongsam of today is no longer restricted to the original style due to significant changes in both cut and material. Many updated, contemporary cheongsams also have fresh stylistic adjustments, advancing them gradually down the path to haute couture [14,15].

Combination of Qipao with Modern CAD Technology and 3D Anthropometry Technology

The automatic generation of an intelligent secondary sample is based on the knowledge of the model, and the design of the sample is realised by the automatic identification of the computer. The clothing customisation software, Like of France, can correct the sample according to the need in a few seconds. Jun-Ming Lu et al. developed a complete and intelligent clothing system that can obtain the size of the body from the 3D image and use CAD technology to manufacture the model, and finally realise automatic cutting, sewing, and inspection. The realisation of the 3D model is to realise the automatic conversion from 3D clothing to 2D cloth. At present, this field is still an important research direction of the 3D virtual human model, and there has been only some preliminary progress in this field in China.

Since the 1990s, with women's growing desire for slimmer figures and the popularity of Chinese trends on the international fashion stage, the combination of Qipao with modern CAD technology and 3D anthropometric technology has attracted attention. Computer-Aided Design is a new development direction. Many people who are engaged in fashion design are doing a lot of work. Based on this, an automatic template modelling method is constructed. On this basis, 300 different types of clothing samples were designed, 300 sets of clothing samples were inputted, 5 specifications were inputted, 23 detailed parameters were inputted, and 8 hidden nodes constituted a 5x8x23 neural network. On this basis, a modification was made to the cheongsam, and dynamic factors were adopted to improve the durability of the structure in the process of weight change. The test data were: bust circumference, waist circumference, abdominal circumference, neck circumference, upper arm circumference, full arm length, shoulder peak distance, back length, and the output data were 7 different parameters, such as bust circumference, neck circumference, sleeve length, garment length, middle waist, shoulder width, and sleeve length. The database consisted of 30 women. This paper also studies the influence of different numbers of neurons, different transfer functions, and different dynamic factors on the performance of 3D neural networks.

Utilising size-driven and feature-driven design, constraints are used to limit the relationship between items. The specific content and significance of size-driven technology is that, under restricted conditions, the parameter size is obtained, but the related information is automatically obtained by the system. Then a size drive control was used to control the shape change, using a GA-BP neural network. In the correlation of a parameter, when a parameter is changed, the value of the corresponding associated parameter also changes. In the design of a pattern, the shape of the pattern can be adjusted by changing the length parameter of the garment. Based on the characteristics of people, the paper is parameterised, and the adjustable parameters are added to the typical geometric shape to provide the basis for more complex patterns.

RESEARCH METHODS

The Qipao style is widely accepted as a popular option thanks to fashion trends. But since the Qipao is so versatile and there is such a strong demand for garments that are incompatible with contemporary lives, the traditional approach to manufacturing it takes a long time. Traditional Qipao styles are no longer able to satisfy individual demands due to the advancement of computer-aided design technology and specific product requirements. As an outcome, parametric clothing design is popular.

Unitary and ternary linear regression techniques may be used to tackle the issue of unscientific garment structures resulting from discrepancies in measurement data. Next, the present structure is optimised utilising the static assessment approach, and CAD technology is employed for parametric design to better satisfy customer and market demands. Enhancing the Qipao style is the goal of this method and meets the evolving needs of the market [16,17].

3D Measurement of Human Body Size

3D measurement of human body size is the process of gathering and evaluating three-dimensional information about a person's physical characteristics using sophisticated technology. This method generates finely detailed images of different body sections using specialist imaging equipment like depth-sensing cameras or 3D scanners. This technology allows for exact clothes fitting, tailored product creation, and individualised health evaluations across a range of industries, including fashion, apparel design, healthcare, and fitness. It also enhances user experience and outcomes, which helps different sectors adopt more specialised and effective approaches. Measuring the human body is necessary to comprehend its form and create clothing. The human body can be measured in order to determine the size of the key body parts and to digitise the distinctive features of the human body. This also allows for more beautiful and close-fitting cheongsam samples and more beautifully designed clothing [18].

Determine the Target

Human bodies vary, so it is difficult to include all scientific researchers, plus the inconvenience of 3D scanners. Therefore, this paper adopts the method of sampling survey and investigates 100 female students in our school [19]. To accurately measure, scan, and analyse the human body's dimensions and outlines, use three-dimensional scanning and imaging. This method provides a more realistic depiction of a person's size and form than conventional tape measures. Identifying desired characteristics for applications such as fitness monitoring, apparel fitting, and healthcare is the main goal of 3D body measuring. Companies in the fashion, fitness, and medical research sectors, for example, may better customise their products and services to meet the unique demands of their clients by gathering extensive and precise data on body measurements. This leads to increased consumer satisfaction.

Test subjects were chosen from a set of criteria that included: female, 18 – 25 years of age, no physical deformities, and tested with informed consent. The participants were all students in the university and had relatively similar body mass indices (BMI: 18.5 - 24.9) for measurement consistency. This reduced variability due to age or body structure in the regression modelling process.

Measurement Method

Conventional body measuring requires a significant level of staff work and complexity to determine the distance between each characteristic point on the human body. More than thirty scales and right- angle rulers are available, along with tape measures and other measuring devices that are often used. It is complicated, time-consuming, and has a major influence on the operator's technical level while providing inexpensive cost, convenience, and simple instrumentation. Traditional measuring offers benefits including affordability, ease of use, and simplicity.

Modern light technology, electronic devices, multimedia, and other cutting-edge medical techniques are used to assess and evaluate the human body in three dimensions in order to determine its non- contact. Currently, the TELMAT stereo scale from AssystBullmer Company in Germany and the Vitussmart stereo human body measuring device from Lectra Company in France are used for stereo human body measurements. Although there are several measuring components and excellent efficiency in the non-contact measurement technique, there is still room for improvement in the measurement accuracy.

The 3D Camega stereo scanning technology from Beijing BoweiHengxin Company, which is outfitted with human parametric software, is used in this research to swiftly identify important body components. Depending on the user's requirements, the device measures every part of the three- dimensional human body, producing data that may be sent to a cloud platform or saved. Four fixed cameras, a computer linked to the cameras, and a foot pedal to maintain the subject's standing posture make up the basic gear. The scanner can produce a 1:1 body stereoscopic map in minutes, scan the whole body, and use measuring software to retrieve the data needed for quick testing [20-22]. The 3D Camega stereo scanning system that was used in the research has a spatial resolution of about 1 mm and an accuracy of ±1.5 mm under normal operating conditions. The Camega operates from 4 fixed infrared cameras in combination with structured light projection, with the system having a scan time of under 10 seconds, reducing posture-induced distortions. The system allows the export of measurement data as standard 3D protocol-free files and can be used in CAD software for patterning. 3D measurement is a method that uses specialised instruments and technology to quantify spatial dimensions inside a three-dimensional space. Structured light systems, dual vision, and scanning with lasers are common techniques. Structured light systems examine forms and deformations, whereas laser scanners produce a point cloud and quantify distances. To triangulate and calculate 3D coordinates, stereo vision makes use of many cameras. With these techniques, accurate spatial analysis is provided for a variety of uses in industries like manufacturing, engineering, healthcare, and entertainment [23].

Measuring Point

The determination target determines the measured area, and its target and position are changed accordingly. This paper discusses the organisational design of clothing fabrics. After analysing the organisational design of clothing fabrics, six parts, such as neck circumference, chest circumference, shoulder width, waist circumference, sleeve length, and hip circumference, are selected and combined with a 3D scanner and manual work. Table 1 shows the standards of measurement.

Table 1. Standards of measurement

No	Measurement standard
1.	The measurement tool used in this test is the stereoscopic body scanning equipment of Beijing BoweiHengxin Company.
2.	During the test, the subjects must wear a grey band tied around their waist with their hair tied high. They must stand in a designated position with their eyes fixed, breathing steadily, and their arms slightly raised beside them.
3.	During the three physical examinations of the subjects, manual measurements and records are required.

Optimising the Sample Design of Cheongsam by Combining the Garment CAD Technology

At present, there are many methods to measure the human body using 3D scanning technology, but its accuracy still needs to be further improved. The actual work of this paper shows that there is a certain deviation between the measurement data of the 3D human body and the measurement data of the artificial human body, which is caused by the slight vibration of the standing posture of the human body, the thoracic changes of human breathing, and the insufficient size of the measurement suit. Therefore, the unitary linear regression method is used to conduct a descriptive study on the measured three-dimensional and manual measurement data of the human body, and the unitary linear regression method is used in the structural modelling of qipao.

After the sampling data is collected, the basic statistical methods are used to describe the sampling data. The sample average is also called the sample average, which reflects the concentration of the data. It is calculated as follows (1):

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{1} \chi_i \tag{1}$$

Standard deviation: This shows how spread the data is around the centre of the mean. The formula (2) is:

$$s = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n} (x_i - \bar{x})^2} \tag{2}$$

The outcomes of an ANOVA research that was performed to assess the linear regression model are shown in Table 2. The validity and strong prediction capacity of the model are confirmed by the statistically significant association between the 3D and manual measurement data, as indicated by the F-value of 123.68 and the p-value < 0.001. This illustrates how the regression-based correction method is dependable for reducing measurement errors and confirming the incorporation of modified 3D data into pattern creation.

Table 2. Basic Statistical Analysis of the Regression Model

	DF	Sum of Squares	Mean Square	F Value	Prob F>
Model	1	1135.30487	1135.30487	123.68075	0
Error	95	872.03513	9.17932		
Total	96	2007.34			

These findings validate the use of linear regression to enhance measurement accuracy and justify the integration of adjusted 3D data into CAD modelling.

The Traditional cheongsam retains the straight line feature of traditional Chinese clothing, but with the influence of Western style, it has evolved into beautiful tights that showcase a woman's figure. The template structure of traditional cheongsam follows the traditional Chinese costume template, with two front and two back shoulder sleeves cut into planar cross shapes. This is completed through plain processes like finishing, pulling, pushing, and ironing to ensure the cloth's integrity and efficiency. Contemporary cheongsam uses a front and back cut, ahem, from shoulder to shoulder, and long sleeves to solve the gap between the chest and waist. This structural design makes the clothes closer to the body, making them more comfortable and attractive.

Organisation Form of Qipao Template Modelling Based On 3D Anthropometry

This is a very critical technical measure. The choice of material structure of clothing directly affects the comfort and beauty of wearing. For example, the design of the chest size can be achieved in white according to the print on the cloth directly, but also to reflect the fit and beauty of the clothing. At present, the mode of organisation and design of the Qipao template has developed to today, and its main form is lithography.

There are two main methods of making the plane: one is the proportional method, and the other is the sample method.

Proportion Method

It has been proved that in practice, the essence of Zheng R's "more fixed clothes" is "clothing-based", which is the "big" clothing system of Ding. This kind of clothing is simpler to use than the method and easy to operate. When there are large differences in clothing installation styles, the calculation method of proportion should be modified accordingly, which is very difficult for designers.

Prototyping

A set of different models can be used for a variety of different styles of clothing. Suitable for personalised clothing and large-scale industrial manufacturing. There are strict formulas for calculating r, time, and suction. There is no strict formula for prototyping and prototype conversion.

Vertical Genre Film

"Stereoscopic tailoring" is a kind of tailoring derived from Western clothing, which is a kind of tailoring carried out in the human body workshop. Modelling clothes on human bodies is a very difficult job. The accuracy of its design is still in practice, and the 3D cutting method is subject to internal constraints such as the shape of the human stage and the design of the handsome, and the three-dimensional sense that can be used needs to be improved. Three-dimensional cutting technology is a popular new style of clothing, and it can be used. The tailoring method is used to adjust the loose volume structure and shape of the tight-fitting clothing.

Rotating In the Transverse Plane

A person's skeletal, muscular, and articular systems are the three musculoskeletal systems involved in movement. Breathing and chest motions are connected, and different segments' range of motion is impacted by muscular contractions. To breathe, the thorax has to be able to move in certain ways. Although complicated shoulder joint movements can be executed in numerous planes at once, abduction and adduction movements are executed by the upper limbs. Movements are carried out in two planes at the elbow joint level. Breathing and movement are facilitated by the contraction of muscles, which influence the movement of different segments. Body proportions vary depending on the upper limbs and trunk. Age, regular activities, work-related activities, food, lifestyle, and the kind and amplitude of exercise all have an impact on these alterations. Anthropometric measures and a range of indications have been used to estimate the dimensional characteristics of the human body. A sample typical of the intended usage has undergone anthropometric tests in order to get its principles varied by gender and age.

$$c_{hk} = W^{(c)} - W_{hk}{}^{(p)} \tag{3}$$

$$fc_{hk} = \frac{W^{(c)} - W_{hk}{}^{(p)}}{W_{hk}{}^{(p)}} 100 \tag{4}$$

In equations (3) and (4) $W_{hk}{}^{(p)}$ represents the static dimensional properties of the human body dimensions measured in the static posture. The following are the meanings of the abbreviations used:

${W_{hk}}^{(p)}$ stands for dimension h of the subject k measured in the static position. It was necessary to separate the data about dynamic effects based on the kind of product and its intended use before using them in the creation of partial or full patterns [24].

The Influence of Different Body Characteristics of Industrial Robot Design on Clothing Styles

The human body is the basis for the design of clothing structure in order to make the clothes more comfortable and more in line with the body characteristics of the human body. The surface characteristics of the human body, to a certain extent, determine the condition of wearing, and to a certain extent, it will also have a certain impact on the organisational model. The characteristic body form plays an important role in the structural design of clothing: neck, shoulders, chest, back, and hips. They exert a certain effect on the overall body shape, thus changing the structure and design requirements of the garment [25].

Neck Type

The neck is connected to the neck by the neck girdle. The neck includes the characteristics of the human body, such as the anterior neck point, the cervical spine point, and the left and right side neck points of clothing structure. Figure 1 shows the necklines.

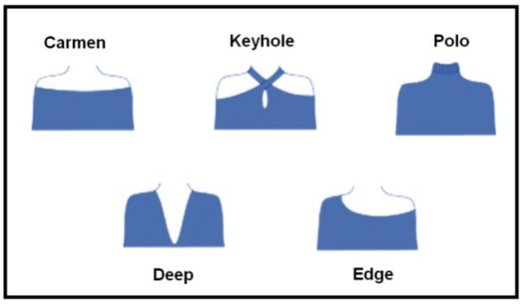

Figure 1. Variations in Necklines

Shoulder Type

As the shoulder is the supporting part of the garment, it plays a great role in the structural design of the garment. In mechanical design, the condition of shoulder tilt is restricted by factors such as body roll angle and trapezius muscle thickness. Due to the increased thickness of the trapezius muscle, the shoulders of hunched people are more inclined than those of people. Figure 2 shows the shoulder angles.

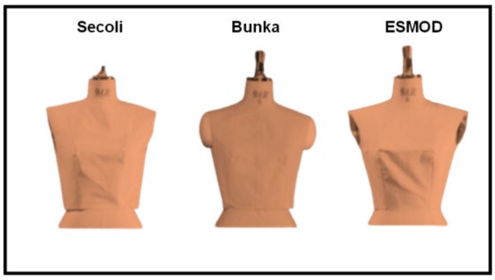

Figure 2. Shoulder angle of garments

In the design of the jacket, the chest is the most prominent and important part. Taking Donghua as an example, the pattern made in Japanese is based on the chest. The amount of chest skimming and the length of the front coat are determined by the curve of the chest and the size of the chest bulge.

Shape of the Back Side

The back is the equivalent of the chest and a key part of the costume. In general, the range of the body forward tilt is relatively large, and a certain amount of scalability should be reserved in the back modelling of the clothing to ensure the movement of the body. Figure 3 shows the backside of garments.

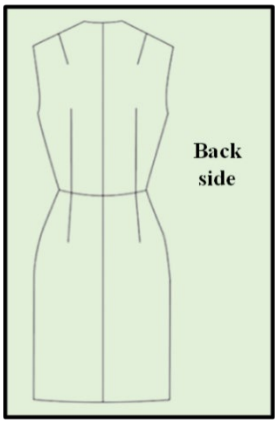

Figure 3. Shape of the back side

Generally, the shoulder blades on the shoulders will be slightly protruding, which will not cause too much impact on the construction of the clothes, and can be solved with shoulder shaping. And the humpback and other special shapes to measure the difference between the length of the front and back waist to determine the size of the humpback; in terms of conventional shape construction, it cannot adapt to the specific shape.

Shape of Waist Circumference

Waist and hips are the main parts connecting the human body. In clothing modelling, the difference between the waist and hips is a key technical link. The connection between the waist, hips, and chest is: the front of the body, the gap between the lower chest and the waist is relatively large; however, at the back of the body, there is a marked indented tendency between the waist and the hips. Figure 4 depicts the waist type.

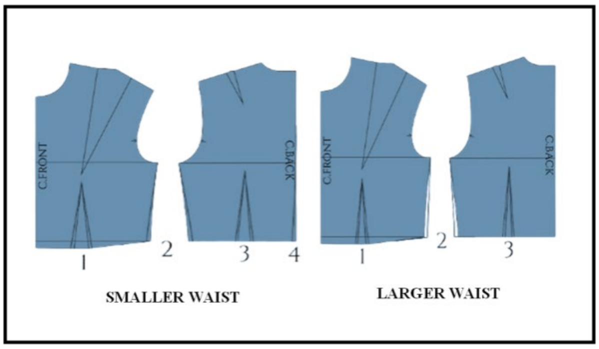

Figure 4. Types of Waist

RESULT ANALYSIS

Comparison of Industrial Robots Participating in Garment CAD Design

The human body is the basis of clothing structure design in order to make clothes more comfortable and more in line with the body's characteristics. The surface characteristics of the condition of wearing, to a certain extent, and the application of 3D anthropometric technology will also have a certain impact on the organisational structure of the body. The features of the body shape play an important role in the structural design of clothing: neck, shoulders, chest, back, waist, and hips. They had an effect on the overall body shape and thus changed the structure and design requirements of the garment.

Neck Type

The neck is connected to the neck by the neck girth. The neck includes the front neck point, the cervical spine point, the left and right side neck points, and other characteristic points of the human body, which play an important role in the design of clothing structure.

Shoulder Type

As the shoulder is the supporting part of clothes, it is the structural design of clothing pieces. In mechanical design, the condition of the shoulder tilt is restricted by the body roll angle and the thickness of the trapezius muscle. Because of the increased thickness of the trapezius muscle, people who are hunched over have a higher angle of the shoulder than they do. (3) The chest is the most prominent and important part in the design of the jacket. Take Donghua as an example, which is represented by Japanese characters, and its patterns are made with the chest as the unit. The amount of breast skimming and the length of the front are determined by the size of the chest curve and the chest bulge.

Rear Shape

The back is the equivalent of the chest and is a key part of the outfit. In general, the body leans forward to a large extent, and the back of the clothing should be reserved for a certain degree of scalability, to ensure the movement of the body. In general, the shoulder blades on the shoulder will slightly protrude, will not cause too much impact on the structure of the clothing, and can be solved with a shoulder pad. The use of three-dimensional anthropometry technology to determine the size of the hunchback according to the measurement of the front and back waist length difference, the conventional form structure cannot adapt to the specific shape.

Waist Shape

From the perspective of 3D anthropometric technology, the waist and hip are the main components connecting the human body. In clothing modelling, the difference between the waist and hip is a key technical link. The connection between the waist, buttocks and chest is: the front of the body, the gap between the lower chest and the waist is larger; on the back side of the body, there is a significant concave tendency between the waist and the buttocks.

Costume CAD Technology Design Based on the Concept of Industrial Robots

Judging by the body parts, the Hip is a body shape composed of the pelvis, greater trochanter, gluteus maximus, and other tissues. It is connected with the waist and crotch by three-dimensional anthropometric technology, forming a very complex body shape. Together with the chest and waist. As can be seen from the analysis below, there is a certain relationship between the structural curves of clothes using 3D anthropometric technology and the parameters of body characteristics. However, sleeve curve and shoulder curve involve more parameters of body characteristics, which are difficult to draw, and require us to carry out an in-depth discussion.

Since fewer tools are used to measure the shoulder contour, other relevant body features must be analysed to draw the shoulder contour using 3D anthropometric techniques. The profile of the shoulder is a combination of the side neck point and the shoulder point, so the profile of the shoulder can be judged by the positioning of the side neck point and the shoulder point. The shoulder is a special straight segment; its construction drawing way is unique.

Figure 5 depicts four different sleeve structures adopt one sleeve shape, and the difference is the height of the sleeve hill and the size of the sleeve hill arc. Methods A, C, and D are obtained according to the sleeve cage arc curve, but their scale factors are different, which are 115, 115, and 14, respectively. Method B is obtained through experience and is a fixed number.

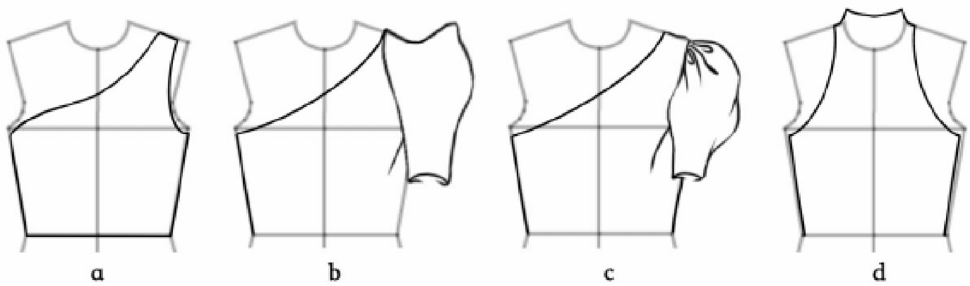

Figure 5. The cheongsam shoulder shape was designed by an industrial robot. (a) scale factors 115; (b) fixed number; (c) scale factors 115; (d) scale factors 14

From the three perspectives of reasonable structure, detail size, and whether it can be parameterised (control of structure line type parameters in drawing), it can be seen from Table 1-2 that method B has more empirical values, which is not conducive to the extraction of parameters. Method A, C, D sleeve hill height is based on the size of the cuff curve, calculate the length and curve of the sleeve hill arc, and the sleeve hill convex of method D is: the front sleeve cage arc is higher than the back sleeve cage arc, the sleeve curve of A and C is smaller than A, the value on the sleeve hill arc is smaller than C, and the sleeve shape of C is better.

As we can see in the overall application, according to whether there are too much subjective judgment factors in the design of the template, detail size, structure design and human design, whether the model of the relation between parameters, for clothing, collar, sleeves, four kinds of structure design has carried on the comprehensive comparison and analysis of the advantages and disadvantages of four kinds of design scheme is obtained: D type clothing structure design is more reasonable; Method B is the best neckline; The cuff structure with C type is more in line with the actual situation.

Garment CAD Technology Design Based on the Concept of Industrial Robot

In terms of body parts. The hip is a kind of body shape composed of the pelvis, the greater trochanter, the gluteus maximum and other tissues, and the waist and hip are connected, which constitutes a very complex body shape, and together with the chest and waist circumference, deciding the curve of the human body, thus affecting the difficulty of the side suture, and the beauty of the dress.

It can be seen from the analysis of the figure below that there is a certain relationship between the structural curve of clothing and the parameters of body characteristics. However, the curve of the sleeve and the curve of the shoulder involve more body characteristics parameters and are difficult to draw, which requires us to conduct an in-depth discussion.

Since the shoulder Angle free tool is used to measure the shoulder contour, other relevant body features must be analysed to draw the shoulder contour. The profile of the shoulder is the combination of the lateral neck point and the shoulder point; therefore, the profile of the shoulder can be judged by the positioning of the contralateral neck point and the shoulder point. The shoulder is a special straight segment, and its construction and drawing way are unique.

As shown in Figure 6, both points are on a line; only the side neck and shoulder positions need to be fixed. After analysis, the distance between the shoulder oblique line, the shoulder endpoint, and the front and back midline is obtained, and the shoulder line is depicted by geometric painting. For example, stitch the shoulder width line from the centre of the front to the side, then draw a curve with the side neck as the centre of the circle and the length of the shoulder line as the radius, and form a shoulder point at the intersection of the shoulder width line. That is, the number of breast savings is following equation (5):

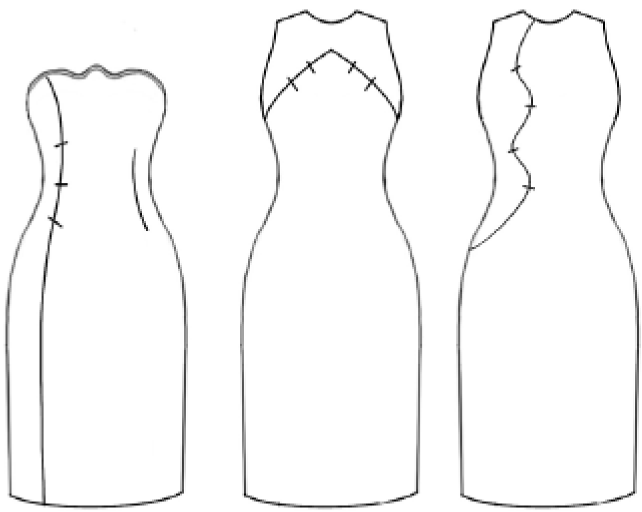

Figure 6. (a) Neck collar button homonymy; (b) Neck collar button both sides; (c) Neck collar button profile

$$\begin{aligned} & \mathrm{H}^2 + \mathrm{r}^2 = \mathrm{R}^2 \\ & \cos\ a = H/R \\ & \theta = 2\Pi(1 - r/R) \end{aligned} \tag{5}$$

In the actual test, it can use the breast rangefinder to measure the Angle of the spine, and then use the Angle of the goniometer, put this number in, get this value, then figure out this value, then add this number in, and you get this result.

Metrics Evaluation

The metrics of performance demonstrating the effective development of the 3D-CAD cheongsam design system are represented in Table 3. The fitting error was most definitely minimised within 2mm, demonstrating adequate conformity to body shape. Production time required was only 1.8 hours to manufacture one sample unit, and the time model was only faster than manual methods by 72%. Enhanced also revealed a price reduction of 55% and precision of approximately 93% also indicating the model's efficiency in the construction of personalised garments.

Table 3. Key Performance Metrics of 3D-CAD Cheongsam Design

Metrics	Values	Units
Fitting Error	2	mm (±1.5–2 mm)
Fabrication Time	1.8	hours/sample
Cost Reduction	55	% compared to the traditional method
Time Savings	72	% faster than manual fabrication
Precision (R^2 Accuracy)	93	% (R^2 = 0.93)
Pattern Accuracy Gain	48	% improvement over manual drafting

CONCLUSION

To sum up, this research selects 100 clothing CAD design devices and 3D body scanning devices from six important links, including the structure of clothing samples, the extraction of neck and chest circumference, and the application of industrial robots. It obtains the best clothing design scheme by means of statistics and quantitative statistical analysis, and carries out parametric design to obtain the CAD parametric model. Using the straight-line method to connect six points can effectively improve the precision of three coordinates. The research is intended to illustrate the best design method of a cheongsam by using 3D anthropometric data together with garment CAD technologies. Using manual and 3D scan measurements, regression techniques, and structural CAD modelling, the research identifies the corresponding effect of specific body features, such as neck, shoulder, waist, and chest, on the pattern design. The methods reveal that Method D gave the best design in a more structurally rational way, Method B gave the best neckline shaping, and Method C provided the best sleeve construction in terms of usability of CAD-based optimised design. By studying the morphological characteristics of the female shoulder, neck, chest, waist, and buttock, the diagonal of the shoulder, cage arc, and chest profile were optimised, and the modelling of a CAD parametric chemical industrial robot cheongsam was obtained through parametric form. Therefore, there are many ways to use 3D scanning technology to measure industrial robots; however, the accuracy of industrial robots needs to be further improved. The actual work of this analysis shows that there is a certain deviation between anthropometric data of the 3D human body and artificial data, which is caused by the slight vibration of human standing posture, the change of human breathing chest, the insufficient size of human clothing, and other factors. The method described in this paper has strong practical significance.

Author Contributions

An Ouyang designed, collected and analyzed the data, and drafted the manuscript. An Ouyang conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. An Ouyang participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflicts of Interest

The author declares no conflicts of interest.

Funding

This research received no external funding.

Data Availability

The data used to support the findings of this study are included within the article.

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