

## Research Article

# The Application of Clothing Intelligent 3D Display with Uncertainty Models Technology in Clothing Marketing

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As a result of the development of new technologies such as satellite communication, digitalization, and multimedia computer networks, new media such as blogs, online magazines, and wireless network media have sparked a lot of interest. This study uses 3D clothing display technologies to improve the customer experience of online clothing marketing, aid in the improvement of online clothing marketing efficacy, and extensively discuss the digital clothing anthropometric model. Furthermore, this study employs the convex hull approach and NURBS fitting technology to address concerns with digital clothing anthropometric measurement and provides a practical solution for measuring straight line length, circumference length, and curve length. Furthermore, this research incorporates 3D intelligent technology to develop an online fitting system as well as an intelligent display system for garments. The simulation experiment investigation revealed that the smart clothing 3D display system proposed in this work has a substantial impact on growing online e-commerce clothing marketing as well as improving clothing marketing effectiveness.

## 1. Introduction

The Internet has gradually become a huge information exchange platform, and the influence of emerging media such as electronic magazines and blogs on this basis has rapidly become prominent. Moreover, mobile phones have broken through the single function of interpersonal communication tools and increasingly have the characteristics of mass media, and more new media have been born under the impact and fusion of old and new media [1]. These new information carriers compete for people's limited attention, change people's work and lifestyle, and also change the marketing methods, marketing scope, and communication effects of enterprises. In today's information dissemination pattern, the competition for marketing information dissemination extends to different terminals, and the fragmentation of the advertising market has become a trend. The emergence of new media enhances the audience's initiative. The audience no longer unilaterally accepts the information

provided by the traditional media but can selectively accept the information and release the information, becoming an important information or information source for the traditional media [2]. At the same time, the emergence of the Internet and mobile phones has brought many new concepts to marketing communication and has also established a good communication and exchange platform for fashion designers, consumers, and enterprises. Therefore, research and analysis of various new media to find a new way suitable for clothing marketing communication have positive practical significance for the construction, promotion, and communication of clothing brands [3].

New retail will integrate online and offline, while traditional retail will separate online and offline. For new retail, the boundaries between online and offline tend to be blurred. Online and offline prices are the same, data is shared, and traffic is drawn from each other. A common strategy is that when consumers place an order and buy a product online, they can arrange for a physical store nearby to ship it. And no

matter which channel consumers purchase through, the data generated will become a reference for marketing plans of various channels. For example, when a consumer purchases a piece of clothing in a physical store through mobile payment, the in-store system will send the consumer to the store. The frequency of purchases, items purchased, and the address of the store are recorded into a registered consumption, and the consumer's consumption habits are accurately pushed in the future. Although traditional retail also has multiple sales channels through physical stores and virtual stores, the two are not directly related, and when the online product resources are insufficient, it is a violation of the rules to take supplements offline. Due to the lack of cooperation between the responsible teams of the two channels and the differences in key performance indicators, they have formed differences in price and even supply.

This paper combines 3D clothing display technology to improve the customer experience of online clothing marketing and assist in improving the marketing effect of online clothing.

## 2. Related Work

Currently, there are several different understandings of the concept of visual merchandising. It can be mainly divided into the following three categories: the first type of view is that visual marketing uses the planning of color, shape, sound, and other aspects of the displayed products to make them have a strong impact on consumers, thereby attracting consumers to enter the store and generating transactions. This kind of point of view focuses more on the visual impact brought by the display and display of goods, so as to promote the sales of goods [4]. The second view integrates visual presentation techniques, merchandise display techniques, and marketing strategies. Emphasizes the importance of visual expression and merchandise display must be combined with marketing strategies [5]. The definition of marketing during this period still stayed within the scope of "commodity terminal store". The last category of views is to extend visual marketing from the scope of "commodity terminal stores" to other scopes on the basis of the first two views, and conduct in-depth research on the psychological impact of consumer purchases [6]. Literature [7] regards the reflection of the psychological phenomenon of "vision" on the individual attributes of commodities as the main factor affecting consumer behavior, and combines visual presentation technology and commodity display technology to formulate a marketing mix strategy that is different from other marketing concepts. Visual marketing uses the visual elements of the terminal store, such as LOGO, store design, advertising, windows, store props, color, lighting, and other visual communication systems to transmit the brand's products, brand positioning, brand culture, and brand connotation to target consumers or potential consumers, thereby achieving good communication between brands and consumers. Visual merchandising reproduces the life and consumption needs of target consumers so as to achieve the purpose of promoting commodity sales and establishing a brand image. Therefore, visual merchandising is one of the most effective strategies for the design system of end stores [8].

Visual marketing covers a wide range, it involves marketing, brand visual identity design, product mix, and display, terminal store design and display, window design, exhibition design, fashion photography, visual design in event promotion, visual design in advertising and other aspects of knowledge [9]. Visual merchandising is built on the basis of marketing and is a new marketing strategy and model. Compared with marketing, visual marketing pays more attention to product design, brand dissemination, and the design and display of terminal stores, emphasizing the influence mechanism of vision on marketing. That is to say, under the guidance of marketing, visual marketing organizes the three visual elements of product function, visual symbol design, and visual language association to convey the brand value of the enterprise to target consumers [10]. Of course, visual marketing also applies the visual marketing process to brand information and visual communication with consumers, and provides goals in product packaging, styling, store layout, merchandise display, advertising, marketing planning, and even overall corporate identification management. For consumer visual impact refer [11]. As a part of marketing, in the process of practice, visual merchandising has been extended from the application of various offline physical stores, such as physical stores, department store retail, and shopping mall, to the industry of network information dissemination and sales; from the visual presentation of technology and products The application of display technology in the field of sales has developed and expanded to include space design, communication planning, and even image recognition of the entire enterprise [12].

Literature [13] defines a brand as six connotations, namely product attributes, users, personality, interests, values, and culture. What can highlight the brand most is the brand's culture, brand personality, and brand value. In the process of consumers understanding the brand, they first experience the attributes of the brand, that is, the function of the product. In the experience, they are gradually attracted by the culture and personality of the brand, thereby further generating recognition for the brand [14]. Ultimately, consumers identify with the value of the brand and form the same values as the brand. For example, when consumers buy clothing, they first try on the clothing to understand the silhouette, color, and style of the clothing product, and then carry out the visual perception of the store image and communication with the store clerk during the try-on process. Understand, and then feel the psychological satisfaction brought by purchasing the brand's clothing and identify with the value of the brand [15]. In the brand building of enterprises, the whole process should be extended in reverse [16]. First of all, enterprises should take the brand's value orientation as the core and use it to shape the brand's culture and personality. On this basis, the target consumers of the brand are positioned, starting from the brand culture and brand personality, to design the product attributes that conform to the consumer group and the benefits the product can provide. Only by placing the value of the brand at the core can the brand achieve good results in its construction and management [17].

The main purpose of visual marketing is to reflect and enhance the brand image in the terminal store, shape the

brand style, strengthen the brand connotation, and make consumers leave a deep impression on the brand. Therefore, clothing companies need to use visual marketing strategies to establish a link window with consumers at the store terminal and establish a unique and personalized image to distinguish them from other brands [18]. The core of visual marketing is to display and display the terminal of the store so that the store image can get the best visual effect, so as to attract and infect consumers, achieve consumers' purchasing behavior, and convey the culture and connotation of the brand in a deeper level [19].

### 3. Clothing 3D Digital Technology

B-spline curve is an extension of Bezier curve, and its general expression is

$$Q(u) = \sum_{k=0}^n B_{k,p}(u) P_k, u_{\min} \leq u \leq u_{\max}, \quad 1 \leq p \leq n+2. \quad (1)$$

In the above formula,  $P_k$  is the control point,  $p$  is the curve order, and  $p-1$  is the curve order. We define the curve to have a continuity of order  $p-2$  at the junction.  $B_{k,p}(u)$  is the  $p$ -order ( $(p-1)$ -order) basis function, which is a piecewise polynomial function.  $B_{k,p}(u)$  is defined as

$$B_{k,0}(u) = \begin{cases} 1 & u_i \leq u \leq u_{i+1} \\ 0 & \text{other} \end{cases},$$

$$B_{k,p}(u) = \frac{u - u_k}{u_{k+p} - u_k} B_{k,p-1}(u) + \frac{u_{k+p+1} - u}{u_{k+p+1} - u_{k+1}} B_{k+1,p-1}(u), p > 1, \quad (2)$$

$T = (u_0, \dots, u_m)$  is the node vector,

$$\sum_{k=0}^n B_{k,p}(u) = 1, \quad (3)$$

$m = n + k$ , and generally, we take the node vector  $h$  as  $T = (\underbrace{a, a, \dots, a}_k, a_1, \dots, a_{n-k+1}, \underbrace{\beta, \beta, \dots, \beta}_k)$ .

NURBS is the abbreviation of nonuniform rational B-spline, which is specifically explained as follows:

**Nonuniform:** it means that the distance between each node is indeterminate (uniform or nonuniform), so the range of influence of each control vertex can be changed.

**Rational:** it means that control points are allowed to be weighted, and each NURBS object can be represented by a unified mathematical expression.

**B-spline:** it refers to a B-spline as a basis function.

**Model point:** that is, the point on the curve and surface. Curves and surfaces are usually obtained by interpolation through known value points.

**Control points:** points that control the shape of curves and surfaces. Usually, the control point and the model

point do not coincide, and the control point is generally not on the curve or surface.

**Node:** the node vector directly affects the B-spline basis function, so the node concept is an important concept in NURBS curves and surfaces. According to whether the nodes are equally spaced, B-splines can be divided into uniform B-splines and nonuniform B-splines.

$$P(u) = \frac{\sum_{i=0}^n w_i P_i N_{i,p}(u)}{\sum_{i=0}^n w_i N_{i,p}(u)} = \sum_{i=0}^n P_i B_{i,p}(u), \quad (4)$$

$$B_{i,p}(u) = \frac{w_i N_{i,p}(u)}{\sum_{j=0}^n w_j N_{j,p}(u)}.$$

In the formula,  $P_i$  is the control vertex,  $i = 0, 1, \dots, n$ .  $B_{i,p}(u)$  is the  $p$ -order ( $p+1$ -order) basis function.

$w_i$  is the weighting factor corresponding to  $P_i$ , and the first and last weighting factor is  $w_0, w_n > 0$  and the rest are  $w_i > 0$  to prevent the denominator from being zero and to preserve the convex hull property, the curve does not degenerate to a point due to weighting factors.

The node vector is  $U = [u_0, u_1, \dots, u_m]$ , and the number of nodes  $m$  is  $n + p + 1$ .

For aperiodic NURBS curves, the repetition degree of the nodes at both ends is often taken as  $p+1$ , and have  $U = [\underbrace{a, \dots, a}_{p+1}, u_{p+1}, \dots, u_n, \underbrace{\beta, \dots, \beta}_{p+1}]$ . In practical applications,  $a = 0, \beta = 1$  is often taken.

The  $B_{i,p}(u)$  basis function has the following properties:

- (1) Nonnegativity,  $B_{i,p}(u) \geq 0$ ;
- (2) Normative,  $\sum_{i=0}^n B_{i,p}(u) = 1, u \in [u_0, u_n]$ ;
- (3) Locality,  $\sum_{i=0}^n B_{i,p}(u) = 0, u \notin [u_i, u_{i+p+1}]$ ;
- (4) Differentiability. In the node interval, when the denominator is not 0,  $B_{i,p}(u)$  is infinitely continuously differentiable;

At the node, if the repetition degree of the node is  $m$ , then  $B_{i,p}(u)$  is differentiable of order  $p-m$ .

- (5) If  $w_i = 0$ , then  $B_{i,p}(u) = 0$ ; if  $w_i = +\infty$ , then  $B_{i,p}(u) = 1; B_{j,p}(u) = 0 (i \neq j)$ .

Since, what is measured is the shape point on the curve, not the control vertex of the curve control polygon, the control point of the curve should be inversely calculated according to the existing data points on the curve. This process is called the inverse calculation of the curve, and the obtained curve is the interpolation curve. Through  $n+1$  type-valued points  $Q_k$ , the  $P$ -th degree NURBS curve equation of  $k = 0, 1, \dots, 11$  can be written as

$$P(u) = \sum_{i=0}^g P_i R_{i,f}(u), \quad u \in (0, 1). \quad (5)$$

The corresponding parameter  $u_k$  of the type value point QK is substituted into the above formula in turn, and the interpolation conditions should be satisfied:

$$Q_k = P(\bar{u}_k) = \sum_{i=0}^n P_i R_{i,p}(\bar{u}_r), \quad k = 0, 1, \dots, n. \quad (6)$$

It is written in matrix form as

$$\begin{bmatrix} Q_0 \\ Q_1 \\ \vdots \\ Q_n \end{bmatrix} = \begin{bmatrix} R_{0,p}(\bar{u}_0) & R_{1,p}(\bar{u}_0) & \cdots & R_{n,p}(\bar{u}_0) \\ R_{0,p}(\bar{u}_1) & R_{1,p}(\bar{u}_1) & \cdots & R_{n,p}(\bar{u}_1) \\ \vdots & \vdots & \ddots & \vdots \\ R_{0,p}(\bar{u}_n) & R_{1,p}(\bar{u}_n) & \cdots & R_{n,p}(\bar{u}_n) \end{bmatrix} \begin{bmatrix} P_0 \\ P_1 \\ \vdots \\ P_n \end{bmatrix}, \quad (7)$$

The element of the coefficient matrix in the above formula is the value of the B-spline basis function at the parameter  $u_k$ , which only depends on the parameter  $u_k$  and its position in the node vector  $U$ .

Parameterization refers to determining a parameter segmentation for a set of ordered data points, that is, the calculation of the parameter  $u_k$ . There are several ways to parameterize data points:

- (1) Uniform parameterization method is

$$\bar{u}_0 = 0, \bar{u}_n = 1, \bar{u}_k = \frac{k}{n} \quad k = 1, 2, \dots, n-1. \quad (8)$$

This parametric method only works when the sides (or chords) of the data point polygon are close or equal.

- (2) Accumulated chord length parameter method:

$$\bar{u}_0 = 0, \bar{u}_n = 1$$

$$\bar{u}_i = \bar{u}_{k-1} + \frac{|Q_k - Q_{k-1}|}{\sum_{j=1}^n |Q_j - Q_{j-1}|} \quad k = 1, 2, \dots, n-1. \quad (9)$$

This parameterization method faithfully reflects the distribution of data points according to the chord length, and overcomes the problem of uniform parameterization when the data points are unevenly distributed according to the chord length.

- (3) Centripetal parameterization:

$$\bar{u}_0 = 0, \bar{u}_n = 1,$$

$$\bar{u}_k = \bar{u}_{k-1} + \frac{|Q_k - Q_{k-1}|^{1/2}}{\sum_{j=1}^n |Q_j - Q_{j-1}|^{1/2}} \quad k = 1, 2, \dots, n-1. \quad (10)$$

This method has a good effect on the parameterization of nonuniform value points, so based on this consideration, this paper intends to use this method to determine the parameter  $u_k$  corresponding to the type of value point  $Q_k$ .

After the parameter  $u_k$  is determined, the node vector  $U$  needs to be further determined. In order to inversely solve the same number of control point vectors from  $n+1$  type-valued points, avoid supplementary boundary conditions, and in order to reflect the distribution of the parameter  $u_k$  corresponding to the type-valued point  $Q_k$  in the parameter

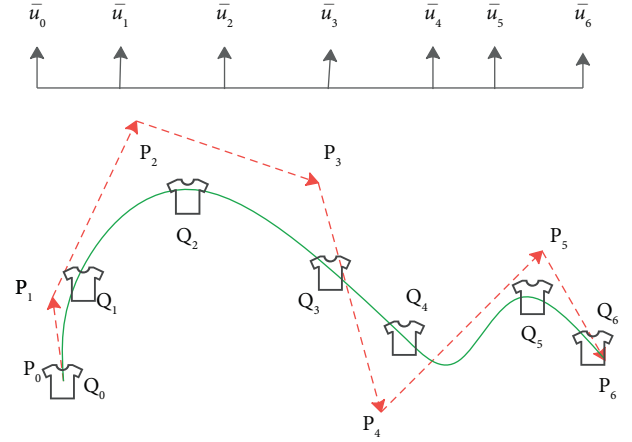


FIGURE 1: Control point, shape point, and node vector of cubic curve.

domain, the algebraic average method is used to construct the node vector  $U$ .

$$u_0 = \cdots = u_p = 0, u_{m-p} = \cdots = u_m = 1,$$

$$u_{j+p} = \frac{1}{P} \sum_{i=j}^{+\beta+1} \bar{u}_i \quad j = 1, \dots, n-p. \quad (11)$$

The node vector is  $U = \{0 = u_0 = \cdots = u_p, u_{j+p}, u_{m-p} = \cdots = u_m = 1\}$ ,  $m = n + p + 1$ .

Figure 1 shows the control points, parameters, and nodal vectors of a cubic NURBS curve interpolating 7 data points.

The measurement method for the straight line length is as follows: it first finds two reference points and their three-dimensional coordinates needed to determine parameters on the digital clothing human body, and then, obtains the parameter values by calculating the horizontal distance, vertical distance or straight-line distance between the two points. The definition of horizontal, vertical, and oblique straight line lengths in the three-dimensional coordinate system is shown in Figure 2. For example, for the human body parameter “milk distance” (definition: the horizontal distance between two breast peak points), it is necessary to locate the three-dimensional coordinates  $P_1(x_1, y_1, z_1)$ ,  $P_2(x_2, y_2, z_2)$  of the two “milk peak points” on the digital clothing human body, and then, calculate the horizontal straight-line distance  $|x_1 - x_2|$  between the two points.

For the concave section on the human body surface of digital clothing, what needs to be measured is a closed convex hull (closed convex envelope), ignoring the concave part. In the previous method, the length of the curve of the concave part is also included in the circumference, which produces an error, and the error will further expand with the increase and enhancement of the concave part of the cross-section. Taking the female thoracic section as an example, Figure 3(a) shows the outline of the thoracic section. Compared with the correct bust measurement reference line shown in Figure 3(b), it can be seen that there is an obvious depression in the middle of the chest, and there is also a certain depression in the spine of the back. If this cross-

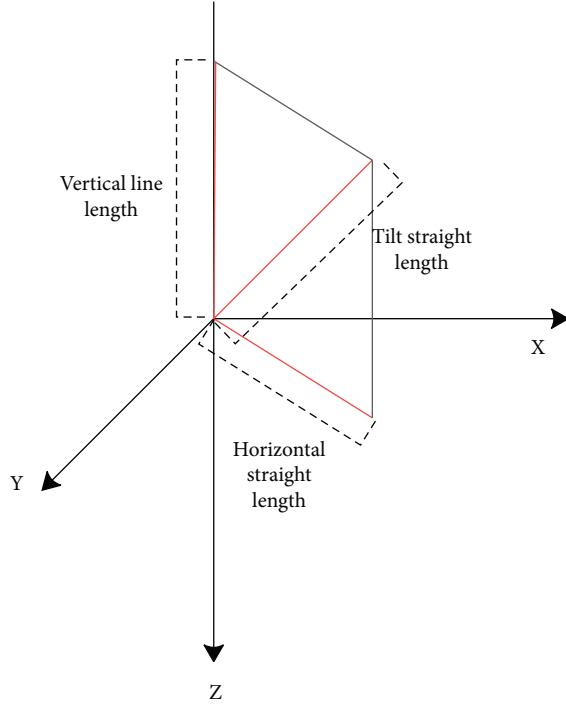


FIGURE 2: Definition of horizontal, vertical, and oblique straight line lengths.

sectional profile is used as the measurement benchmark for the bust, a large error will occur.

In view of this, this paper introduces the convex hull algorithm to correct the cross-section after NURBS fitting, so as to remove the influence of the concave parts of the human body on the circumference measurement.

Concept of convex envelope: the convex hull of a point set  $Q$  refers to a minimum convex polygon that satisfies the points in  $Q$  either on the polygon edge or within it, as shown in Figure 4.

In order to facilitate the measurement, this paper modifies the Graham scanning method according to the actual requirements of the measurement. The initial point sequence is sorted according to the polar angle, so that the remaining point sequence after the convex hull algorithm is still in the original order.

The specific method is as follows:

- (1) The algorithm determines the point with the largest  $y$ -coordinate value in the cross-section point column after NURBS fitting as the starting point  $P_0$ . If there is more than one, the algorithm takes the point with the smallest  $x$ -coordinate value as the starting point  $P_0$ , and renumbers the remaining points in turn:  $P_0, \dots, P_i, \dots, P_{n-1}$ .
- (2) The algorithm pushes the first three points  $P_0, P_1, P_2$  into the stack.
- (3) For the remaining points, the algorithm calculates the cross product  $(P_i - P_{i-1}) \times (P_{i-1} - P_{i-2})$ , ( $3 < i < n$ ) in turn. If  $> 0$ , the algorithm pushes  $P_i$  onto the stack. If  $< 0$ , the algorithm removes  $P_{i-1}$

from the stack, calculates  $(P_i - P_{i-2}) \times (P_{i-2} - P_{i-3})$  again, and repeats step 3.

- (4) Finally, after all the points are calculated, the remaining points in the stack are the point set  $P_0, \dots, P_{m-1}$ , ( $m < n$ ) after removing the concave points.

We assume that the inclined contour line passes through  $m$  horizontal sections, and each section is represented by 30 type-valued points, that is, there are  $m$  point columns:  $S_0, \dots, S_{m-1}$ , and each point column includes 30 points:  $P_0, \dots, P_i, \dots, P_{29}(x, y, z)$ . We need to use these  $m$  point columns to construct a point column to characterize the desired sloped contour, denoted by  $S_m$ .

Next, the three-dimensional coordinate point column  $S: P_0, \dots, P_i, \dots, P_{29}(x, y, z)$  is transformed into the two-dimensional coordinate point column  $S': P'_0, \dots, P'_i, \dots, P'_{29}(x', y')$ . The coordinate transformation relationship is as follows:

$$\begin{cases} x' = x \\ y' = \pm \sqrt{y^2 + (z - z_0)^2} \end{cases} \quad (12)$$

If  $y > 0$ , it is positive; if  $y < 0$ , it is negative.

Among them,  $z_0$  is the  $z$ -coordinate of the center point of the section (the  $x$ -coordinate value and the  $y$ -coordinate value are both 0).

After obtaining the two-dimensional coordinate point series, the method of measuring the horizontal girth is used: first use the NURBS fitting technique, and then use the convex hull algorithm to correct the measurement, and then the parameter data of the oblique girth can be obtained. For the above methods, we can also make some optimizations by adjusting the steps. The method is as follows: then, after determining  $m$  point columns:  $S_0, \dots, S_{m-1}$ , the algorithm first performs NURBS fitting on them, and then, after obtaining  $S'$ , the girth, can be directly calculated. This can improve part of the accuracy, but at the same time,  $m - 1$  times of NURBS fitting will be used more, which increases the overhead of the system. The effect of neck circumference measurement is shown in Figure 5.

The length of the curve refers to the length of the curve from one point to another point on the human body of the digital clothing. Similar to the measurement of the length of a straight line, it also needs to first determine the two endpoints of the parameter and their three-dimensional coordinates  $P'(x_1, y_1, z_1), P''(x_2, y_2, z_2)$ . The measurement methods of horizontal, vertical, and inclined curve lengths are discussed separately below.

Since, the horizontal circumference is a closed curve (special curve), any horizontal curve on the digital clothing body is a part of the contour line on the same section as it. That is, for any horizontal curve on the digital clothing human body, there is a contour line on the same section, and there is a many-to-one relationship between them. If the point column of a curve corresponding to the contour line is  $P_0, \dots, P_i, \dots, P_{29}$ , and the positions of the two endpoints of the curve in the contour line point column are:

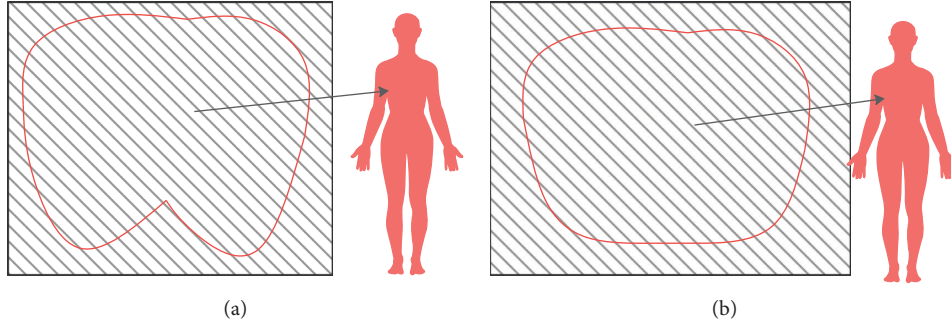


FIGURE 3: The outline of the thoracic section. (a) Thoracic section outline. (b) Bust line.

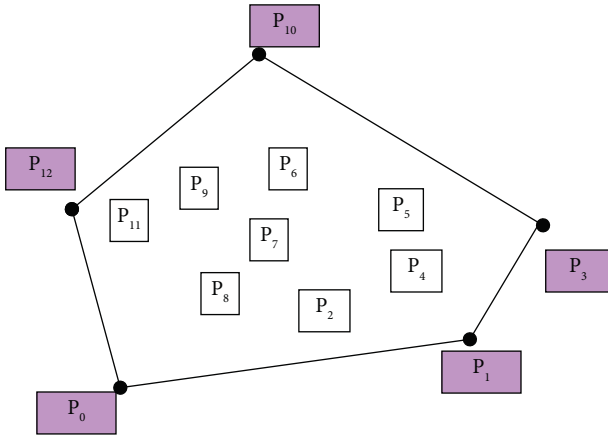


FIGURE 4: Definition of convex envelope.

$\begin{cases} P' = P_j \\ P'' = P_k \end{cases} \quad (0 < j < k < = 29)$ . Then, we only need to use NURBS fitting for each point in between  $P_j \sim P_k$ , and then selectively use the convex hull algorithm as needed to calculate the length of the curve ( $P_j \sim P_k$ ).

First, the algorithm needs to determine the starting point  $P'(x_1, y_1, z_1)$  and the ending point  $P''(x_2, y_2, z_2)$  of the vertical curve. Then, the algorithm sequentially determines the points of the vertical curve on each section it passes through. We assume that the vertical curve passes through  $m$  horizontal sections, each section is represented by 30 type-value points, that is, there are  $m$  point columns:  $S_0, \dots, S_{m-1}$ , and each point column includes 30 points:  $P_0, \dots, P_i, \dots, P_{29}(x, y, z)$ . Moreover, we need to use the points in the  $m$  point columns to construct a point column to characterize the vertical curve, which is represented by  $S$ .

For the parameters of the front and back of the digital clothing human body, the  $x$ -coordinate of  $P'$  is consistent with the  $x$ -coordinate of  $P''$ . We can find a point in each point column of the  $m$  horizontal cross-section point columns that the vertical curve passes through to form  $S$ . The criteria for selecting points in the point column are as follows: the  $x$ -coordinate is closest to the  $x$ -coordinate of  $P'$ , and the  $y$ -coordinate and the  $y$ -coordinate of  $P'$  are both positive and negative (function: determine whether the point is on the front or the back). After finding these points, the

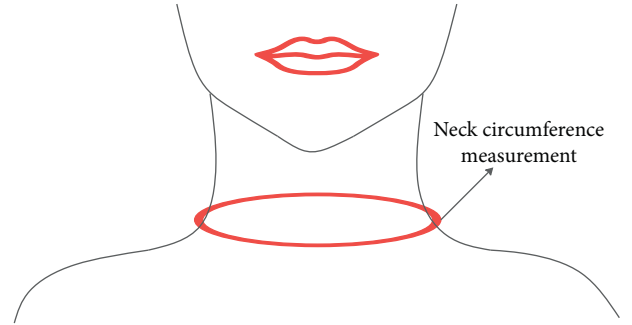


FIGURE 5: Neck circumference measurement chart.

algorithm changes the  $x$ -coordinates of these points to the  $x$ -coordinates of  $P'$  to keep them vertical, then uses NURBS fitting, and then optionally uses the convex hull algorithm as needed, and finally gets the length of the vertical curve. As shown in Figure 6(a), it is the orthographic projection of the length of the vertical curve on the front and back. Figure 6(b) is the side projection of the vertical curves on both sides.

For the parameters on both sides of the human body of the digital clothing, the  $y$ -coordinate of  $P'$  is consistent with the  $y$ -coordinate of  $P''$ , and we can find a point in each point column of the  $m$  horizontal cross-section point columns that the vertical curve passes through to form  $S$ . The criteria for selecting points in the point column are as follows: the  $y$  coordinate is closest to the  $y$  coordinate of  $P'$ , and the  $x$  coordinate and the  $x$  coordinate of  $P'$  are the same positive and negative (function: determine whether the point is on the left or right side). After finding these points, the algorithm changes the  $y$ -coordinates of these points to the  $y$ -coordinates of  $P'$  to keep them vertical, then, uses NURBS fitting, and then optionally uses the convex hull algorithm as needed, and finally gets the length of the vertical curve.

The measurement of the length of a sloped curve is very similar to the measurement of the length of a vertical curve, but there are differences. The  $x$ -coordinate of  $P'$  and the  $x$ -coordinate of  $P''$  or the  $y$ -coordinate of  $P''$  and the  $y$ -coordinate of are no longer equal, so the criteria for selecting points in the  $m$  horizontal cross-section point columns that the inclined curve passes through have changed. The line connecting  $P'$  and  $P''$  has an intersection with each section it passes through (Figure 6(c)).

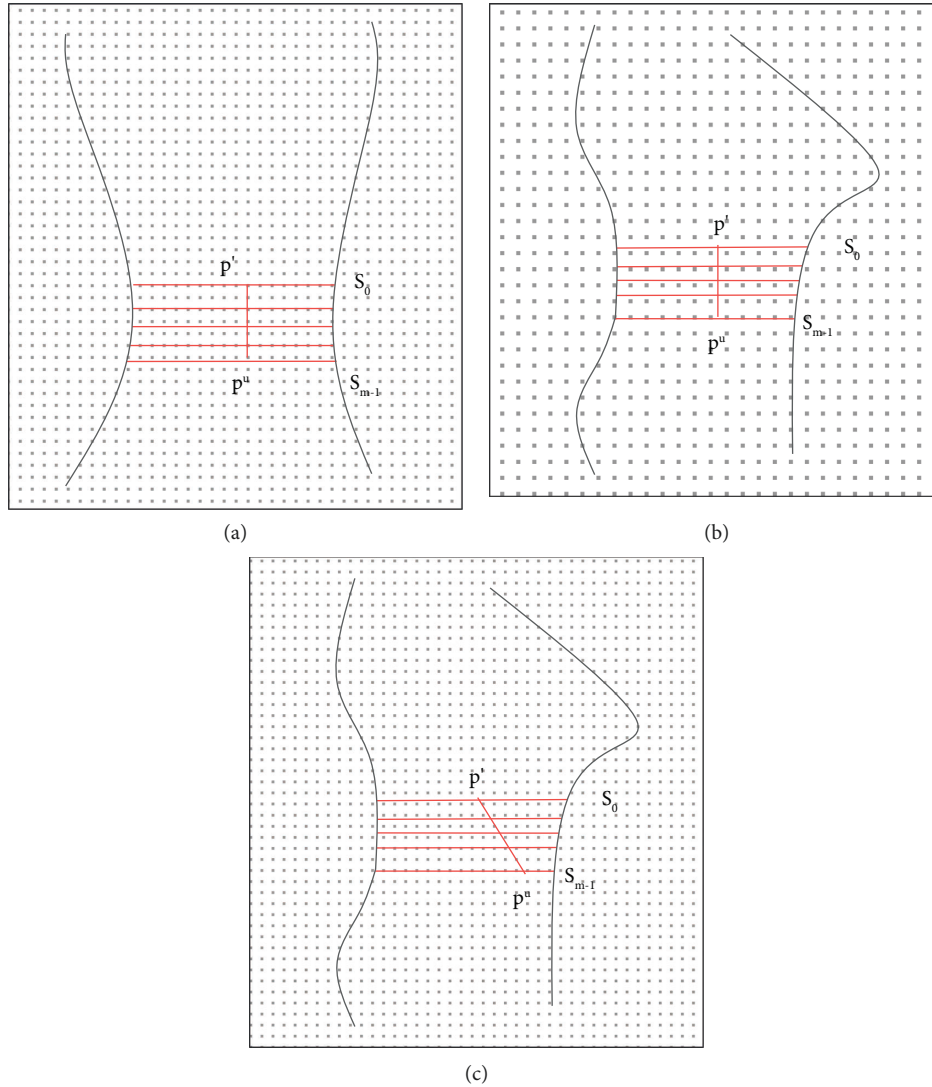


FIGURE 6: Projection of digital clothing human body. (a) Orthographic projection of the length of the front and back vertical curves. (b) Side projection of vertical curves on both sides. (c) Side projection of the length of the inclined curve.

For the parameters of the front and back of the digital clothing human body, the criteria for selecting points in the point column are as follows: the  $x$ -coordinate is closest to the  $x$ -coordinate of the intersection of the line and the section, and the  $y$ -coordinate and the  $y$ -coordinate of the intersection are the same positive and negative (role: determine whether the point is on the front or the back). After finding these points, the  $x$ -coordinates of these points are changed to the  $x$ -coordinates of the intersection, so that their slopes remain the same. The following steps are the same as for the measurement of the vertical curve length.

For the parameters on both sides of the human body in digital clothing, the criteria for selecting points in the point column are as follows: the  $y$ -coordinate is closest to the  $y$ -coordinate of the intersection of the line and the cross-section, and the  $x$ -coordinate and the  $x$ -coordinate of the intersection are both positive and negative

(function: determine whether the point is on the left or right). After finding these points, the  $y$ -coordinates of these points are changed to the  $y$ -coordinates of the intersection, so that their slopes remain the same. The following steps are the same as the measurement of the vertical curve length.

For the measurement of vertical curves and inclined curves, it is also possible to perform NURBS fitting on each cross-section profile point column that the curve passes through to improve part of the accuracy, but also to increase the system overhead. In addition, it should be noted that the measured curve must pass through at least 3 or more cross-sections. The reason for this is that NURBS fitting requires at least three control points. Considering that such short parameters are rarely found in natural anthropometric measurements, the impact on digital clothing anthropometric measurements is not significant.

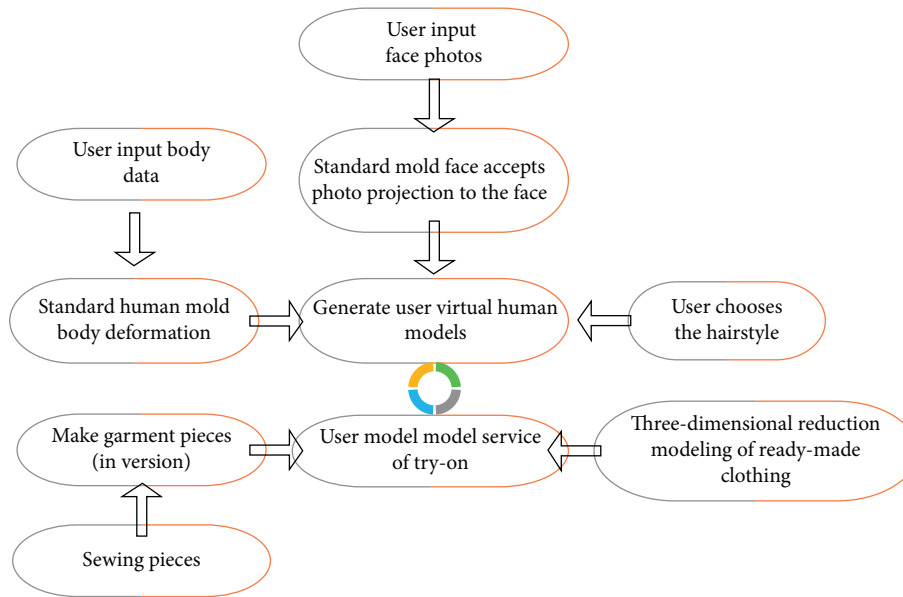


FIGURE 7: The interactive process of the 3D virtual fitting system.



FIGURE 8: Schematic diagram of smart 3D clothing display.

#### 4. Application of Clothing Intelligent 3D Display Technology in Clothing Marketing

This paper combines intelligent 3D display technology to construct a clothing marketing system that can not only display clothing but also have the function of fitting. The

interactive process of the 3D virtual fitting system is shown in Figure 7.

Figure 8 shows the schematic diagram of smart 3D clothing display.

After the above system is constructed, the clothing display function and online fitting function of this system are



TABLE 1: Verification of clothing display effect.

Num	Fashion show
1	79.350
2	75.380
3	71.406
4	72.418
5	70.938
6	82.348
7	82.050
8	73.013
9	70.764
10	74.884
11	71.676
12	84.746
13	68.860
14	73.617
15	74.395
16	81.480
17	79.173
18	74.229
19	69.612
20	68.856
21	81.495
22	83.289
23	72.842
24	80.815
25	76.738
26	85.352
27	77.633
28	74.273
29	70.009
30	84.026
31	86.666
32	82.729
33	69.661
34	68.226
35	84.942
36	79.536
37	84.715
38	67.344
39	82.139
40	67.822
41	68.731
42	75.762
43	72.036
44	69.388
45	71.753
46	71.623
47	86.238
48	72.837
49	69.780
50	67.995
51	81.069

TABLE 2: Functional verification of online fitting.

Num	Online fitting
1	65.510
2	65.457
3	74.324
4	68.890
5	60.927
6	71.183
7	67.949
8	67.758
9	64.360
10	73.887
11	64.207
12	66.932
13	78.858
14	70.275
15	64.457
16	60.851
17	79.989
18	61.076
19	60.530
20	60.544
21	77.139
22	72.075
23	64.711
24	68.105
25	73.945
26	79.365
27	80.740
28	64.559
29	60.964
30	74.236
31	75.028
32	64.977
33	68.655
34	72.523
35	63.403
36	75.182
37	72.234
38	72.136
39	76.951
40	63.589
41	76.474
42	74.941
43	78.450
44	76.956
45	62.036
46	75.778
47	66.953
48	68.916
49	67.550
50	78.488
51	69.860

tested and evaluated in combination with simulation experiments, and the results shown in Tables 1 and 2 are finally, obtained.

From the abovementioned research, it can be seen that the smart clothing 3D display system proposed in this paper can effectively improve the effect of clothing marketing and has an important role in promoting online e-commerce clothing marketing.

## 5. Conclusions

The new retail operation approach places an emphasis on “scenario triggering,” in contrast to the more traditional method of retail operation, which frequently keeps marketing material and the scene apart from one another. Consumers who are in a physical store and see a favorite article of clothing but do not have a size that is suitable for

them at the moment have two options: they can scan the QR code to search for inventory, or the relevant brand app can send personalized push notifications to target consumers who are in close proximity to the physical store using location-based service technology. With this strategy, it is possible to achieve mutual draining between online and offline activities in an effective manner.

The purpose of this paper is to improve the customer experience of online clothing marketing by utilizing 3D clothing display technology. Additionally, this paper will assist in increasing the marketing effect of online clothing. As a result of the simulation test research, it has been established that the smart clothing 3D display system that has been proposed in this article has the potential to significantly enhance the effect of clothing marketing and that it plays an important part in the promotion of clothing marketing through online e-commerce.

### Data Availability

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

### Conflicts of Interest

The authors declare that they have no conflicts of interest.

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### References

- [1] Q. Xu, H. Liu, Y. Liu, and S. Wu, "Innovative design of intangible cultural heritage elements in fashion design based on interactive evolutionary computation," *Mathematical Problems in Engineering*, vol. 2021, Article ID 9913161, 11 pages, 2021.
- [2] S. Bogović, Z. Stjepanović, A. Cupar, S. Jevšnik, B. Rogina-Car, and A. Rudolf, "The use of new technologies for the development of protective clothing: comparative analysis of body dimensions of static and dynamic postures and its application," *Autex Research Journal*, vol. 19, no. 4, pp. 301–311, 2019.
- [3] M. Man-Lok Lam, E. P. Li, E. Yee-Nee Lam, and W. S. Liu, "Aesthetic experiences and design creativity: an ethnographic study of a wool felting design workshop," *International Journal of Fashion Design, Technology and Education*, vol. 14, no. 3, pp. 375–386, 2021.
- [4] X. Zhang and C. Yang, "Application of Multipopulation Genetic Algorithm in Industrial Special Clothing Design," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 1632063, 9 pages, 2022.
- [5] B. E. Jin and D. C. Shin, "The power of 4th industrial revolution in the fashion industry: what, why, and how has the industry changed?" *Fashion and Textiles*, vol. 8, no. 1, pp. 31–25, 2021.
- [6] S. Starkey, S. Alotaibi, H. Striebel, J. Tejada, K. Francisco, and N. Rudolph, "Fashion inspiration and technology: virtual reality in an experimental apparel design classroom," *International Journal of Fashion Design, Technology and Education*, vol. 14, no. 1, pp. 12–20, 2021.
- [7] S. Saleh Alghamdi, S. John, N. Roy Choudhury, and N. K. Dutta, "Additive manufacturing of polymer materials: progress, promise and challenges," *Polymers*, vol. 13, no. 5, p. 753, 2021.
- [8] D. Kodžoman, "The psychology of clothing: meaning of colors, body image and gender expression in fashion," *Textile & Leather Review*, vol. 2, no. 2, pp. 90–103, 2019.
- [9] C. Black, C. Freeman, and A. Rawlings, "Problem-based learning: design development of female chef's jackets," *International Journal of Fashion Design, Technology and Education*, vol. 11, no. 1, pp. 123–128, 2018.
- [10] Y. Zhao, "Manufacturing personalization models based on industrial big data," *Journal of Discrete Mathematical Sciences and Cryptography*, vol. 21, no. 6, pp. 1287–1292, 2018.
- [11] S. Kolose, T. Stewart, P. Hume, and G. R. Tomkinson, "Cluster size prediction for military clothing using 3D body scan data," *Applied Ergonomics*, vol. 96, Article ID 103487, 2021.
- [12] J. Park, K. Park, B. Lee, H. You, and C. Yang, "Classification of upper body shapes among Korean male wheelchair users to improve clothing fit," *Assistive Technology*, vol. 31, no. 1, pp. 34–43, 2019.
- [13] S. Miell, S. Gill, and D. Vazquez, "Enabling the digital fashion consumer through fit and sizing technology," *Journal of Global Fashion Marketing*, vol. 9, no. 1, pp. 9–23, 2018.
- [14] S. Y. Kim and J. Ha-Brookshire, "Evolution of the Korean marketplace from 1896 to 1938: a historical investigation of Western clothing stores' retail and competition strategies," *Clothing and Textiles Research Journal*, vol. 37, no. 3, pp. 155–170, 2019.
- [15] P. Milošević and S. Bogović, "3D technologies in individualized chest protector modelling," *Textile & Leather Review*, vol. 1, no. 2, pp. 46–55, 2018.
- [16] T. Maxmudjon, "The figurative expression of the composition of costume," *Innovative Technologica: Methodical Research Journal*, vol. 2, no. 10, pp. 38–42, 2021.
- [17] J. Louis-Rosenberg and J. Rosenkrantz, "Anti-entrepreneurs using computation to unscale production," *Architectural Design*, vol. 90, no. 2, pp. 112–119, 2020.
- [18] S. K. Seo and C. Lang, "Psychogenic antecedents and apparel customization: moderating effects of gender," *Fashion and Textiles*, vol. 6, no. 1, p. 19, 2019.
- [19] A. Ihsan, N. Fadillah, and C. Rizka Gunawan, "Acehnese traditional clothing recognition based on augmented reality using hybrid tracking method," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 20, no. 2, pp. 1030–1036, 2020.