Research on the Application of Personalized Customized Virtual Design Method in Clothing

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ABSTRACT

In order to meet the different needs of customers at different stages of personalized customization of clothing, this paper analyzes the status quo of personalized customization of clothing under the "Internet +" environment, and puts forward the concept of ergonomics. Based on the dynamic holographic model of apparel 3D virtual design, real-time dynamic record of clothing modeling information in order to amend and improve. Based on the dynamic holographic product model of apparel products, the 3D virtual garment design method is applied in clothing personalized customization, and the clothing modeling based on physical-geometric mixed model is optimized; a skirt as an example of this study was analyzed. This paper summarizes the virtual design method, which makes the garment manufacturing industry realize the human-machine collaborative design on the basis of network technology, and the reality is stronger. This paper summarizes the virtual design method in the garment manufacturing industry based on the network technology to realize the human-machine co-design of clothing, the reality is stronger.

KEYWORDS

International Conference, International Conference, International Conference.

INTRODUCTION

The core of personalized apparel informatization customization is "polymerization", which includes users, designers, apparel fabrics provider, garment production enterprises, logistics and other resources of all-round aggregation. Detailed flowchart diagram is shown as Fig.1.

Personalized Apparel Customization, it applies modern computer and network technology, the human body measurement, style selection, shape analysis, garment design and other links organically combine to achieve rapid personalized customized apparel production. But the customer's demand on the network is often not fast and accurate to the effect of rendering, so that customers see the effect of the picture can not really feel the effect of finished products, cannot be timely to modify the product design. Therefore, the key of garment network customization is virtual design method.
RESEARCH ON VIRTUAL DESIGN METHOD IN GARMENT CUSTOMIZATION

In order to better design the needs of people's clothing, clothing design method of virtual application cannot be ignored. The research on the authenticity of the garment model and the rapid response of the system is lacking in the comprehensive various modeling methods. Therefore, this paper proposes the virtual design technology of garment 3D based on dynamic holographic product model.

Apparel Dynamic Holographic product model

The method of garment virtual design based on holographic product model combines the product and environment definition data, the interaction between the two is dynamic response, and the product information of "multi-dimensional" is obtained, and the efficiency of virtual design and development product is improved. Holographic product modeling is the product in the whole life cycle of various applications in the field of modeling and analysis, the product in the relative application of the domain of the definition of data and environmental data simulation technology. Using virtual reality technology to describe the image dynamic response of the product in each application field, and finally compare the knowledge base and rule base to this description.

Assuming the holographic product model is $M^H$, it appears as an "image" in an application domain. Order, the application of the i-field "image" is $M_i^S$, then the holographic product model is $M^H = \bigcup_{i=1}^{m} M_i^S$. Suppose the product definition data model is $M^P$, the environment Definition model is $M^E$, then the product definition data
model and the corresponding environment definition data model in the application of the i-field are \( M_i^P \), \( M_i^E \). Set action operator to \( T_i \), it represents the interplay between products and environments, and each "image" includes the factors that interact with data, product definition data, and environment definition data. Then the mathematical expression of each "image" is:

\[
M_i^S = M_i^P T_i M_i^E
\]

Considering the role of products and environments in the product lifecycle, and the interactions between "images", innovative designs are continually updated, and dynamic models are required to reflect these abstractions. Then, the holographic product model of this time is \( M^H = \bigcup_{i=1}^{m}(M_i^S + M_i^S) \), among them \( M_i^S = \bigcup_{j=1}^{m} T_j M_j^S \) ( \( m_i \leq m \), \( M_i^S \in M^H \)) \( T_i \) for each "image" interaction factor). The dynamic response of a dynamic holographic product model in an application environment is shown in Fig.2 below:

The development method of virtual costume design based on dynamic holographic product model is the application of the theory and method of holographic product model in the process of virtual costume design. The process can be divided into three layers: the garment target design layer, the garment virtual manufacturing model construction layer and the Garment Application field simulation analysis layer.

1. The garment target design layer mainly includes the demand proposal, the plan design, the function analysis and so on several phases. Its main task is to establish a good garment design in the early stage of the virtual apparel to meet the needs of goals, apparel design drawings, clothing decorative pattern craft and garment production and manufacturing process, so as to establish a model for the definition of clothing data preparation. For the garment function analysis this stage, namely characteristic analysis, if is multi-characteristic, then the function breaks down into 1,2,..,n, then carries on the analysis to the structure element and the mechanism element corresponding to the function to determine the garment product structure form.

![Diagram](image)

**Figure 2.** Dynamic response of a dynamic holographic product model in an application environment.
(2) Garment virtual Manufacturing Model construction layer it is based on the target design layer to establish a definition of clothing product data model \( M^P \), at the same time the definition of data for testing and analysis. It includes the establishment of three-dimensional geometric model of the definition data element in the garment structure in CAD software, defines the data element selection material for garment structure, associates the corresponding attribute data, and sets the data element of each structure definition. Then, according to the structure and functional characteristics of the garment, the structure of the movement constraint, rule constraint and knowledge constraint are imposed. Rule constraint and knowledge constraint are the embodiment of knowledge in costume design process, they make garments conform to all kinds of norms at the beginning of design, conform to the basic design principle, and the experience and wisdom of designers are also fused. The process of inspection and analysis is the consistency and interference inspection of all the defined data models of garments, and the SKU, category and color of the garment are analyzed to further optimize the garment structure form.

(3) The Garment Application field simulation analysis layer it refers to the garment fabrics in the corresponding application environment, style and process design, garment production process, such as simulation analysis, in order to from the garment product application angle and production angle, the structure and performance of garment products to further validate and optimize. This has to be in each application area to establish the corresponding clothing definition data model and corresponding environment definition data model respectively \( M^P_i \), \( M^E_i \). \( M^P_i \) is the "materialization" of its application field on the basis of \( M^P \). \( M^E_i \) is the definition of the data model of the environment that the garment products will have in different fields of application. In the applications of performance simulation, virtual machining, virtual assembly and virtual testing, through the establishment of garment processing service Core ontology model (including equipment level, cutting sewing equipment, processing quality, processing cost, etc.), "Porter five forces" model, such as environmental model, so that the definition of apparel products and environment data interaction, so as to apparel fabrics, styles and process design processes, apparel production process, garment production process, clothing test process to wear dynamic simulation.

Virtual design of garment 3D based on dynamic holographic product model

Garment modeling is the key to virtual design technology. 3D Virtual reality technology is a kind of advanced man-machine interface, which is characterized by the rich effect of immersion in virtual reality, large display ability and strong interactivity. We have to rely on 3D human scanning system, using non-contact 3D human measurement technology to generate digitized human body surface data, so each customer has its own unique body model. Then, virtual map the human body data to the plane, design the contour of the garment, and then through the corner detection, contour lines and the determination of the intersection line, generate three-dimensional clothing data. Finally, customers can choose according to the clothing and their own body size to get their own model of three-dimensional clothing display, customers can see the full range of clothing wear effect.

Considering the subjective and objective factors of man-machine interface in ergonomics, the emphasis is on the characteristics and limitation of human being, the
human factor is the whole process of garment design. Using the dynamic holographic product model to make the 3d virtual design of the garment will include the human dynamic factors into consideration, the standard is to see whether the virtual garment products meet the human size, living habits. Living habits here, such as what kind of clothes the customer wears, what kind of tight clothes the customer wears, consider the collision factors of the human garment, and the speed and efficiency of the design system to respond quickly to human needs. Then, according to these factors, the conception of the garment 3d virtual design system based on the dynamic holographic product model is the following:

(1) Modeling with geometric-physical mixing. In the process of graph generation or simulation, the geometric method is used to obtain the approximate contour, then the physical constraint and parameter conditions are used to refine the local structure, thus obtaining the vivid and fast analog graph, and the garment layering is simulated according to the region in reference [9].

(2) Establishes geometric constraints and dimensional constraints. In order to realize the parametric design of 3D model, the structure of garment should be restrained and geometric constraint, the design object is analyzed systematically, so the design features and dimensions can reflect the corresponding design knowledge, and are encapsulated in the design product.

(3) Determine the design variable. The variable reflects the subjective factors and the dynamic influence factors of the holographic dynamic product model.

(4) According to various parts of garment products including clothing pocket, buttons, 3D printing and other design dimension attribution, step-by-step define assembly relations and order. The system can display the assembling position of each part on the screen according to the Assembly transformation matrix, so that the user can inspect the assembled model from the graph.

(5) The structural analysis of the key parts of garment products, such as shoulder seam, chest, waist section, armpit, and other need for kinematics and dynamics analysis.

The composition of 3D virtual garment design system based on holographic dynamic product model as shown in Fig.3:

Figure 3. 3D Virtual garment design system based on holographic dynamic product model.
In practical applications, the development of virtual products based on holographic dynamic product model can be developed for all phases, from garment product design, process to performance simulation application process, can dynamically reflect product application domain image, then, the realization of data integration is conducive to the development of products after the establishment of product definition data model \( M^p \), if the product function or response data is not satisfied, it can be traced back to the product definition data model \( M^p \) for correction or optimization. This way through the analysis, synthesis, deduction, such as a series of complex activities, the manufacturing of apparel systems, materials, equipment and innovation. Of course, clothing modeling is also a key link in the rapid response of garment virtual design.

**Optimization of geometric-physical hybrid modeling of apparel**

The State Key laboratory of Zhejiang University proposes a hybrid model of costume simulation for integrating geometric and physical deformations. According to the regional partitioning factor, it can be classified into tight layer, floating layer and loose layer three-layer costume model. Using the skin model to calculate the deformation of the tight layer, the loose layer adopts the spring-particle model, the deformation of floating layer is calculated by the near-rigid model after the tight layer and loose layer, so as to ensure the real-time computation efficiency of garment modeling.

The vertex motion of the garment model of the tights is relatively large in relation to the motion of human surface, thus adopting a local-based skin deformation algorithm, which can specify the corresponding skeleton and the corresponding weights for each skin vertex through the graphical interface. The algorithm is faster, but the joints of the human body such as elbow, armpit, knee bending, the skin is compressed, penetrating and so on, the emergence of "collapse", the skin algorithm simulation will produce distortion. Therefore, the fitting-layer garment modeling based on improved skin algorithm is proposed to increase the additional joints.

The skin is divided into variable and immutable regions, the current torsion angle of each joint in the variable region is \( \theta_i^v \), the rotation angle of the binding position is \( \theta_i^b \), then the rotation angle of the joint point is: \( \theta_i = \theta_i^b - \theta_i^v \).

The final torsion angle for the vertex \( P_i \) of the human model is: \( \theta_i = \sum_{i=0}^{\infty} \omega_i \theta_i^b \).

Rotate Transform angle: \( \Delta \theta = \theta_i - \theta_i^b \).

An additional matrix of variable regions of human body models:

\[
M = \begin{bmatrix}
1 & 0 & 0 & 0 \\
0 & \cos(\Delta \theta) & -\sin(\Delta \theta) & 0 \\
0 & \sin(\Delta \theta) & \cos(\Delta \theta) & 0 \\
0 & 0 & 0 & 1
\end{bmatrix}.
\]

According to the change of the triangle position of each body, the coordinates of corresponding vertex of garment are calculated.

\[
v_i' = M t \sum_{\left[v_n\right]} O_n + \left[w_{p,v\cdot x}, w_{p,v\cdot y}, w_{p,v\cdot z}\right] \left[X_{p,v}, Y_{p,v}, Z_{p,v}\right]
\]
Among them, $v_i$ is a garment vertex, $p_i$ is the human body model vertex, $\{T_p,\}$ is the adjacent triangle set, $\{X_p, Y_p, Z_p,\}$ is the local coordinate system constructed by each $T_p$, $O_p$ is the center of gravity of the triangle $T_p$, i.e., the origin of the local coordinate system.

This is based on the tensile skin technology, to add auxiliary joints to the skin variable area, greatly improved the deformation effect of joints, so that special joints such as elbow simulation smoother, 3D realism better effect.

The spring-particle model used in loose layer is to treat the fabric as a mass of virtual particles, and each particle has the corresponding quality and is connected with the particles around it to simulate different mechanical properties of the fabric by stretching, bending, shearing, and other springs. The particles are subjected to various forces including spring force and damping force formed by the internal force and gravity, joint forces and other external forces to deform the fabric. The implicit Euler algorithm is used in the literature [9], the method has high computational stability, and the costume simulation results are good, but the material performance of fabrics is simple. Since the mapping process of 2D to 3D can be viewed as a motion system with time change, the motion of particles can be determined by Newton's second law, as follows:

$$m_i \frac{\ddot{x}_i}{c^2} = -\delta \frac{\dot{x}_i}{\dot{c}} + \sum_j g_{ij} + f_i$$

Wherein, $m_i$ represents the mass of a particle, and $x_i$ denotes the position of the particle, and $\delta$ indicates the resistance coefficient, and $g_{ij}$ represents the elastic spring of the particle i and j to the particle i, and $f_i$ denotes the external force acting on the particle i.

In the spring-particle model, the deformation force of Springs is the internal force to consider, which is also the key to the performance of fabrics. Using Hooke law to calculate elastic deformation force of springs, set there is a particle $p_0$, its adjacent particle set is $Q$, then the effect of the elastic deformation force $f_{elast}$ of $p_0$ has:

$$f_{elast} = \sum_{i \in Q} C_e \left( \left\| p_0p_i \right\| - \left\| p_0p_i \right\|_0 \right) - N_{p_0p_i}$$

Among them, $C_e$ is the spring deformation coefficient, is based on the material performance parameters of fabrics. $\left\| p_0p_i \right\|$ refers to the distance $\left\| p_0p_i \right\|$ between $p_0$ and $p_i$ in t time, $N_{p_0p_i}$ is the unit vector of $p_0$ pointing $p_i$.

In general, the spring between $p_0$ and $p_i$ adopts the same spring coefficient, so that the classification of springs, including structural springs, shear springs, and flexible springs is not distinguished, but also affects the fabric effect. In this case, the three kinds of springs are optimized by different spring stiffness, which corresponds to the tensile, shearing and bending performance of the fabrics one by one. At the same time, if the deformation degree of the same spring is different, the spring stiffness also takes different values. For example, the elastic curves of natural fibers in the literature [14] are determined by the slope of the curves, the tensile elasticity coefficient of fabrics, and the bending stiffness of fabrics are calculated in the literature [15].
EXAMPLE ANALYSIS OF COSTUME VIRTUAL DESIGN METHOD

Take a dance skirts for example. In the design of the concept of apparel products, the design of the uniform requirements can make employees to wear the comfort of work, then the design of the clothing to ensure the tensile deformation degree, clothing pressure. First, the requirements task is decomposed into, $F_1$: the problem of tensile deformation of garment; $F_2$: the problem of the pressure of clothing; then the paper analyzes the essential factors and structural elements of the uniform mechanism to solve the above problems, and determines the 3D model.

Next, the garment product model construction layer needs to establish the Uniform product definition data model and the environment data model, and simulate the working function of the uniform through the interaction between the two models. Considering the tensile deformation and pressure of garment, the main problems are embodied in the key nodes of garment clothing, such as shoulder, chest, waist section, etc. Product definition Data Meta identification for these key nodes (table 1).

Garment Product Definition Data Model consists of the product definition data element in the table above, which is composed of certain position constraint and motion constraint. Each product definition number element is assembled by the position constraint, then add the product's movement constraint, such as whether the sleeve can be disassembled, waist section whether to rope body and so on. And then we construct a dance skirt.

Clothing products in the circumstances of the incentive of objects, product definition data between the position constraints and movement constraints will be affected each other, the occurrence of incentive chain transmission, so the clothing tensile deformation, pressure response to the impact of the user's comfort. Here products are subjected to external incentives for garment modeling when the force, the use of spring-particle model, products will be subjected to their internal forces and action on the external force of the product. The internal force is naturally the elastic deformation force of garment $e_1$, i.e., the tensile, shearing and bending stiffness of the material. The external force has gravity $e_2$, the joint force $e_3, e_8$ exerted on the suture of six places such as coat, shoulder, armpit seam, clothing elbow, shoulder, BP point, garment chest, garment back, transverse gear and so on collision with human inverse collision force $e_9, e_{14}$ and resistance $e_{15}$. The performance of garment products is embodied in the interaction of this product and environment, and the schematic diagram of its interaction is illustrated in Fig. 7.

<table>
<thead>
<tr>
<th>name</th>
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<td>Notch</td>
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<td>Button stand</td>
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<tr>
<td>Shoulder</td>
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<td>Waist province</td>
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<td>BP</td>
<td>PU3</td>
<td>Buttonhole</td>
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<td>Waistline</td>
<td>PU4</td>
<td>princess seam</td>
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<td>Chest</td>
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<td>back seam</td>
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<tr>
<td>Bottom</td>
<td>PU6</td>
<td>crotch</td>
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<tr>
<td>Cuff</td>
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TABLE 1. PRODUCT DEFINITION DATA META TAGS.
Application field simulation analysis layer of garment products is the application environment of apparel fabrics, apparel production and other apparel products performance simulation to achieve the user needs of the comfort degree. In the second chapter, the author introduces the expression of the garment's own internal force, and shows that the elastic deformation force of garment is decided by the elastic deformation coefficient $C_e$, whereas $C_e$ according to the material performance parameters of the fabric, the smaller the garment distortion when the elastic properties of the fabrics are large. Similarly, the sewing force of the garment is applied to the stitching edge of the garment, and the distance between the suture points is linear function.

$$f_{scum} = C_s \cdot \|p_i - p_j\| \cdot N_{p,p}$$

When the suture coefficient $C_s$ is bound, the greater the distance between the suture point $p_i$ and $p_j$, the greater the stitching force.

The collision force $f_{penalty}$ of the garment with the human body is:

$$f_{penalty} = C_p \cdot \exp\left(\|p_{p} - p_{i}\|^{-1}\right) \cdot N_{p_i}$$

The greater the inverse collision coefficient, the greater the inverse collision force. Damping force the velocity function that is subjected to a particle oscillation:

$$f_{damp} = -c_d \frac{\partial x_i}{\partial t}$$

When the faster the particle movement, the greater the resistance of the damping force, clothing will produce an unreal elongated deformation.

By formula (6) The analysis of the resultant force of the garment particles is:

$$m_i \frac{\partial^2 x_i}{\partial t^2} = -C_d \frac{\partial x_i}{\partial t} + \sum_{i \in Q} C_e \left(\|p_0 - p_i\| \cdot N_{p_0,p_i} + m_i g + C_s \cdot \|p_{p} - p_{i}\| \cdot N_{p,p} + C_p \cdot \exp\left(\|p_{p} - p_{i}\|^{-1}\right) \cdot N_{p_i} + C_s \cdot \|p_{p} - p_{i}\| \cdot N_{p,p} + C_p \cdot \exp\left(\|p_{p} - p_{i}\|^{-1}\right) \cdot N_{p_i}$$

$$\frac{\partial^2 x_i}{\partial t^2} = a$$

The formula (11) is the dynamic response characteristic data of the required product definition metadata (acceleration of particle motion $a$), the hermit analytic formula between the product definition data and the excitation data (resistance to damping force, elasticity, gravity, suture force, anti-collision force). Because the equation is nonlinear, it depends on the computer. The resulting clothing is not distorted in the case, by the particle acceleration can be seen, the larger a particle, the greater the force, pull back in situ faster, then the better the elasticity of clothing, the
more tensile performance is better. If the garment model distortion, then can also go back to the Garment product definition data link, product constraint information timely correction.

CONCLUSION

The management of personalized apparel products customized production has updated solutions, and in the virtual design implementation strategy, adopting the method of dynamic holographic product model, setting the dynamic factor, clothing personalized customization Whether in the garment product design, style design, craft design or effect display has important practical significance, can be based on the design effect, always retroactive to any issue and make changes. Using 3D virtual design technology based on the physical-geometric mixing model, the garment modeling from the perspective of network, at the same time to optimize the model, making the model more smooth, in addition to considering the performance of the fabric of the material is more realistic, so that the garment manufacturers to meet the requirements of collaborative design, can be more effective, faster, more economical to complete the development of apparel design, design show intuitive convenience.

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