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Protecting and innovating China's Yao Clothing Heritage: A Digital Perspective

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Abstract

This research explores the contemporary preservation and development of northern Guangdong Yao women's traditional clothing, recognized as part of China's first batch of national intangible cultural heritage. Focusing on the application of digital design tools, particularly CLO3D, the research investigates how technology can optimize the design process, enhance heritage preservation, and inspire contemporary fashion. Through field research, qualitative and quantitative analysis, and digital design techniques, the study explores CLO3D's effectiveness in digitizing Yao costumes, streamlining workflows, and creatively reinterpreting traditional aesthetics. The findings reveal that CLO3D not only effectively protects the cultural heritage of clothing but also enables designers to explore and innovate with traditional design elements in modern fashion. This research offers valuable insights for integrating intangible cultural heritage into contemporary design practices, ensuring its sustainable development while maintaining cultural authenticity. By bridging tradition and innovation, the study contributes to the broader discourse on preserving cultural heritage through digital means and fostering its relevance in modern fashion industry.

Keywords

CLO3D platform, Intangible Cultural heritage, Sustainable conservation development, Digital conservation, Clothing creative design process, Yao traditional clothing

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Introduction

The Yao people are a prominent ethnic minority in Guangdong Province, China. Their distinctive costumes were recognized as part of China's first national intangible cultural heritage list in 2006. The Yao population in Guangdong is primarily concentrated in the northern regions, collectively known as "Northern Guangdong," including Liannan, Lianshan, Lianzhou, Yangshan, Ruyuan, Shixing, Sanshui, and Huaiji. Among the Yao branches, the Paiyao and Guoshan Yao are the most notable in this region, with this study focusing on the clothing of Paiyao women in Liannan Yao Autonomous County.

With the evolution of modern aesthetics, the development of traditional clothing faces significant challenges, making the protection and inheritance of Yao traditional costumes heritage increasingly urgent. Current research on Yao costumes predominantly examines their history, branches, distinctive features, and cultural significance. However, there is limited research on the internal structure of Yao costumes from the perspective of clothing professionals. Additionally, while digital technologies like CLO3D have been widely used to simulate and recreate historical and contemporary garments, their application in preserving and innovating Yao clothing remains underexplored.

This research aims to fill this gap by investigating the potential of CLO3D in digitizing, preserving and designing Yao clothing.

Specifically, the study explores the following key questions:

How can digital methods be employed to effectively extract and analyze design elements from traditional Yao clothing during the early stages of the virtual design process?

What strategies can be adopted to leverage digitalization for innovative and creative design applications that maintain the integrity of Yao clothing heritage?

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How can the effectiveness of virtual clothing designs generated using CLO3D be evaluated and validated in the context of contemporary fashion trends?

Which stages of the digital preservation and creative design process for Yao clothing can be optimized using CLO3D and other digital tools?

By addressing these questions, this research contributes to the preservation and revitalization of traditional clothing through the application of digital technologies. It also seeks to promote the sustainable development of national costume arts by leveraging CLO3D's virtual display capabilities to protect and inherit Yao costume culture.

Literature Review

Yao Traditional Clothing Design Research

The Yao people's costumes have been the subject of extensive research, focusing on the various branches' history, unique design features, and cultural significance (Long & Pan 200; Deng et al., 2008; Li, 2004; Chen, 2013). Comprehensive research on the embroidery color schemes among different Yao branches as well as the animal motifs, such as the deer pattern has aided in furthering the understanding and preservation of the Yao clothing (Xie, 2015; Xie et al., 2020).

The literature on national costume design inspiration and clothing design thinking encompasses a wide range of topics and approaches. (Garrett, 1994) provides an illustrated guide to Chinese clothing, emphasizing twentieth-century costume and the rich colors and delicate cloths of Chinese fabric design. (Mete, 2006) explores the creative role of sources of inspiration in visual clothing design through empirical studies, emphasizing the nature of design inspiration and its impact on creativity. (Ermilova, 2020) explores costume as a form of visualizing ethnicity, tracing the historical perspective of costumes as informational and sign structures.

Research on Innovating Traditional Designs

By drawing inspiration from historical costumes, ethnic traditions, and artistic movements, designers can create garments that not only reflect the past but also push the boundaries of modern design. Russian Constructivism, a movement that emerged in the early 20th century, emphasized abstract and geometric designs in various art forms, including costume design (Park, 2010). This movement aimed to integrate art into everyday life and industry, showcasing a shift towards more innovative and unconventional design approaches. Additionally, Kato et. al. (2019) proposed a method for generating clothing images for pattern makers using GANs, emphasizing the potential for fashion design without the need for a fashion designer.

In more specific areas of innovative design research, Jiang & Dong (2020) identified color and pattern cultural elements within Yao costumes of northern Guangdong and employed them in modern designs. Further, Xu et al. (2021) analyzed the psychological impact of color in Lian Nan Paiyao clothing, proposing innovative design approaches that aligned with specific color significance. Investigations have also been carried out to test the potential of incorporating Yao embroidery elements into commercial fashion design (Jia & Feng, 2011). Ye (2015) also focused on the basic unit patterns of Yao embroidery in northern Guangdong, but further innovated by integrating them with motifs from other ethnic cultures to create new pattern designs.

Regarding the structure of traditional clothing, research has explored methods to improve and modernized traditional flat-cutting methods (Zhao, 2009), analyze the sleeve and crotch structures of national costumes (Fan, 2019) and explore the overall composition of traditional female costumes of the Guoshan Yao in Ruyuan, northern Guangdong (Hu et al., 2020).

Foreign research experts predominantly present their explorations of traditional Yao clothing through pictures and descriptive texts, summarizing the morphological characteristics and cultural connotations. These studies often focus on the modeling characteristics, materials, colors, production technology, functionality, and intrinsic culture of the costumes, showcasing the external appearance of national attire (Chen, 1987).

These studies collectively contribute to the understanding of national costume design inspiration and clothing design thinking, highlighting the importance of cultural heritage, innovation, and visual representation in the field. Through the thoughtful integration of traditional elements and innovative ideas, designers can create clothing that resonates with consumers and contributes to the rich tapestry of global fashion.

Research on the CLO3D Platform

Observing the fashion industry's history, scholars show that digital transformation has accelerated, with virtual technology becoming crucial for innovative design and further creativity (Boughlala & Smelik, 2024). Recent studies have utilized CLO3D for virtual simulations of various traditional costumes including Han Chinese clothing, the traditional Chinese cheongsam as well as European costumes (Chen et al., 2022; Zhang & Ma, 2021; Hu & Song, 2021; Sun et al., 2020). Studies have also explored its application for ancient clothing restoration (Liu et al., 2022; Wang & Wang, 2023; Yue, 2021). Chen & Zhou (2018), Luo et al. (2022), Lee & Kim (2019) explored the application of virtual fitting technology of digital clothing design software CLO3D and Style3D in modern clothing design. Habib and Alam (2024) studied the comparison between 3D virtual pattern making and traditional pattern making. Research into combining CLO3D with other software, such as After Effects, has also been conducted to create dynamic 3D apparel (Choi, 2022). Other scholars have studied the clothing modular design system based on virtual 3D technology (Wang & Zhong, 2022) and the virtual fabric design and simulation system (Fontana et al., 2005).

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In terms of virtual clothing design process, Liu (2015) proposed the idea of applying the methods and processes of user experience design to the interactive virtual display design process of ethnic costumes. Tan & Bai (2023) reviewed the development and improvement of virtual fitting technology based on two-dimensional images, and introduced the commonly used human body features, data sets, loss functions and evaluation indicators in virtual fitting technology in detail.

Li et al. (2023) studied the design method and process of virtual creative draping based on the human-computer interaction form by using the clothing 3D pattern making software Style3D as a platform. Li et al. (2022) studied the intuitive three-dimensional presentation of the garment effect of textile fabric design and the full-process creative design experience of three-dimensional clothing virtual display. Zhu et al. (2017) developed a digital intelligent tailor-made system for men's suits. Deng et al. (2022) organically combined three-dimensional virtual technology with intangible cultural heritage dance costumes to realize a miniature clothing museum based on the three-dimensional cloud display of intangible cultural heritage dance costumes on the Internet. Zhang et al. (2021) digitized the entire process of customized design of knitted Polo shirts, realizing the digital full-process customized design from virtual design to fabric production. Zhang & Ma (2022) took flat embroidery as an example and discussed the implementation steps of the virtual representation of this needlework in the SD and CLO3D platforms.

Papahristou & Bilalis (2017) highlighted the importance of integrating digital prototyping tools in fashion product development. (Meng et al., 2012) discussed computer-aided clothing pattern design with 3D editing and pattern alteration, showcasing the advancements in technology for pattern creation. the implementation of CLO3D for 3D pattern production has been shown to reduce human error, save time, and cut costs in the fashion industry (Hartanto, 2020). Wang & Cho (2021), Huang & Huang (2022) further explore the application of ClO3D in virtual display methods for wetsuits and down jackets, respectively. These studies demonstrate the versatility of Clo3D in the process of creating virtual representations of different types of clothing.

Despite these advancements, few studies have focused on the application of CLO3D in preserving and innovating traditional clothing structures, particularly for Yao costumes. This research aims to fill this gap by leveraging CLO3D's capabilities to digitize, preserve, and creatively design Yao clothing, contributing to the sustainable development of national costume arts.

Research Methodology

To gather firsthand information, an on-site investigation was conducted two times in Liannan Yao Autonomous County, a significant Yao ethnic area in northern Guangdong. The survey covered towns such as Sanpai, Sanjiang, Damaishan, Zhaigang, and Nangang. A total of 26 Yao villagers, including local government officials, traditional embroidery artisans, and community members, were interviewed. Visits to local embroidery workshops provided further insight into modern Yao clothing and cultural products.

First, traditional Yao costumes were researched and analyzed through collection, photography, shape measurements, and structural drawings. Second, online and offline questionnaires were designed to assess the awareness and acceptance of Yao clothing among 327 respondents, including local Yao villagers, tourists, and consumers. Finally, innovative designs were proposed based on these findings, which were simulated using CLO3D for virtual display and produced as physical samples for comparison.

Preliminary Preparation for Virtual Display Process of Innovative Yao Costumes

To analyze the representative formal and daily costumes of the Yao people, we employed a two-pronged approach. First, precise measurements were used to create vector-style drawings of the costumes using Photoshop and Illustrator, facilitating a detailed analysis of their stylistic structures. Second, the patterns of real garments were digitally restored and segmented into their smallest units, allowing for a comprehensive examination of pattern characteristics.

Building upon the existing classification framework for Yao costume patterns, we systematically categorized the patterns observed in the surveyed costumes (Zhang & Yang, 2024). This analysis provides a valuable foundation for understanding the diversity and complexity of Yao clothing design.

To inform the design process, a comprehensive survey of consumer preferences regarding Yao clothing styles and shapes was conducted. The data collected from 327 respondents were analyzed to identify potential areas for innovation in terms of clothing styles, pattern elements, and colors.

Virtual Design Mid-term

To bridge the gap between traditional Yao patterns and contemporary consumer aesthetics, this study integrated market research with a deep analysis of traditional pattern elements. Techniques such as deformation, symmetry, and repetition were employed to create innovative patterns that resonate with both cultural heritage and modern sensibilities. The design process focused on preserving and maintaining traditional cultural values while incorporating modern aesthetics. By analyzing the formation mode, style, color structure, pattern, and cultural connotations of Yao clothing, the design process aimed to reflect the national spirit and material cultural traditions people (Golovnev, 2017; Kondrateva, 2000).

After finalizing the initial innovative design patterns and styles, groundwork was established for mid-term digital virtual design. The process of innovating the virtual design and display of Yao ethnic costumes begins by designing structural patterns using ET pattern-making software. These patterns are then exported in DXF format and imported into the CLO3D platform. In CLO3D's 2D window, the pattern positions are adjusted, and a virtual model is created in the 3D window for further editing.

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Using the sewing line tool, patterns are arranged, cut, sewn, and aligned, with the simulation observed in 3D. This process concludes the preliminary preparations for virtual display.

Subsequently, clicking on the simulation allows users to visualize the preliminary effect of the clothing model. The display presents the front, left, right, and back views of the three-dimensional model. The garment is seamlessly stitched to fit the virtual model's body naturally, considering the effects of gravity. The simulation also incorporates light and shadow effects, with completed sections being locked first to ensure an accurate representation.

CLO3D's mapping tool was used to seamlessly integrate the traditional patterns, in PNG format, into the 2D design space. These patterns were then strategically applied to specific garment components, including the cuffs, sleeves, and collars of jackets, shirts, and linings. The one-to-one mapping tool allowed for precise pattern placement, ensuring the final design harmoniously blends traditional elements with contemporary aesthetics (Figures 1).

Figure 1. Virtual Simulation design flow chart of CLO3D.

The 2D window facilitated the integration of innovative Yao ethnic patterns, while the 3D window provided a dynamic visualization of the garment's overall effect. This interactive approach enabled rapid experimentation with various pattern combinations. Using the same methodology, two clothing sets were designed and virtually simulated on the CLO3D platform.

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This research showcases the innovative potential of clothing design, the transformation of traditional Yao ethnic patterns into contemporary forms, and the effective preservation and transmission of traditional clothing culture.

Post-production of virtual design: Comparative evaluation of the effects of wearing actual clothing and virtual display

Setting Parameters

The CLO3D virtual fitting process involves configuring various parameters, primarily related to the model and fabric properties. Model parameters are adjusted within the software's human model editor, allowing for precise customization of the virtual model's body measurements. Specific values for each body part ensure the model accurately represents the desired fit. For the final garment simulation fitting in this experiment, the model dimensions were set as follows: height 175.26 cm, chest circumference 80.64 cm, waist circumference 60.96 cm, upper hip circumference 80.33 cm, shoulder width 37.78 cm, and neck circumference 35.56 cm. These measurements ensured a realistic representation of the target wearer's physique, enhancing the accuracy of the virtual fitting simulation.

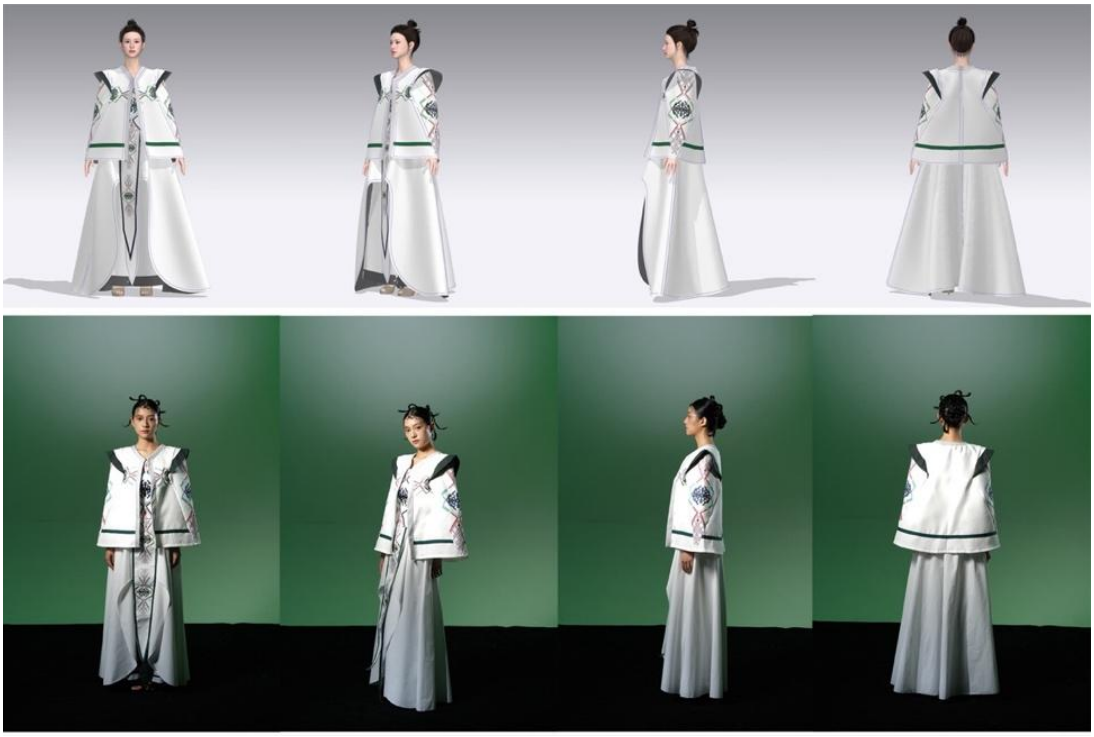
Fabric parameters in CLO3D encompass material properties and performance characteristics such as composition, elasticity, density, strength, color, and drape. Careful selection of these values enhances the simulation's accuracy and realism. The fabric parameters are visually represented.

Comparative Analysis of Virtual and Physical Samples

To solve the problem of how to evaluate and verify the validity of virtual clothing designs generated using CLO3D in the context of contemporary fashion trends, two sets of physical garments were created based on the CLO3D designs. A comprehensive comparison was made between the virtual garments and the physical samples, examining the front, 3/4 side, side, and back views (Figures 2). This analysis provided insights into the advantages and limitations of virtual simulation for Yao ethnic clothing design.

To assess the accuracy of the virtual fitting simulation, real-life models with body shapes matching the virtual models in CLO3D were selected to try on the innovatively designed clothing. By comparing the actual fitting results with the virtual simulation, the study evaluated the congruence between the two.

A final market survey was also conducted, collecting 103 responses. Participants compared the 3D virtual display to the physical display of the clothing series. The results showed that 83.49% of respondents found the virtual and physical displays to be relatively consistent or very consistent. Only 2.91% considered them inconsistent or very inconsistent. These findings demonstrate a high level of consistency between the 3D virtual display and the physical garments. The results suggest that virtual fitting technology effectively simulates garment structure, fabric, color, and overall shape, providing a reliable representation of the final product.



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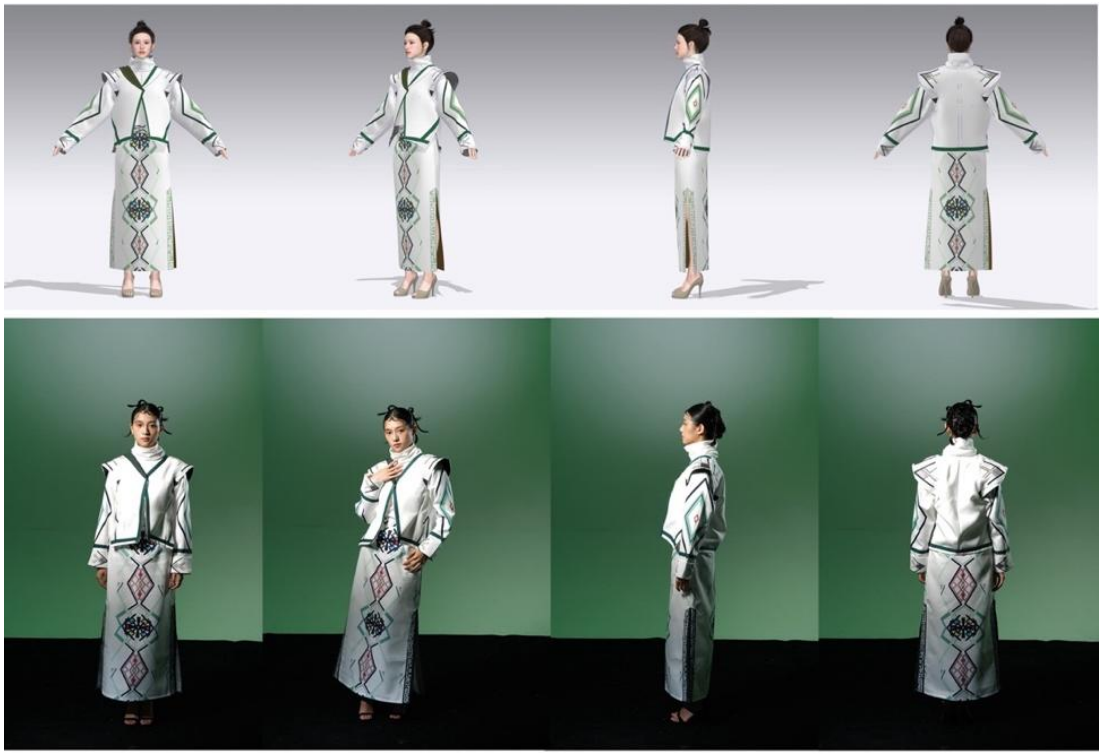

Figure 2. Comparison of the Front, 3/4 Side, Side, and Back of the Ready-to-Wear and Virtual Fitting Garments

Results and Discussion

Although CLO3D has shown significant advantages in digitalization and innovation of clothing, current research lacks a methodology and adaptable model that can systematically ensure that cultural authenticity is accurately preserved throughout the digital redesign process. Using this research, authors developed a model for preservation and innovation of traditional clothing. This model is not only applicable to Yao clothing but can also extend to the digital protection and innovation of other ethnic clothing traditions, while taking into account the differences between different cultures. This model serves as a valuable reference for future research endeavours in traditional clothing design. The findings are presented in three phases: initial, intermediate, and terminal, each highlighting the advantages of CLO3D in the extraction and innovative design process (Figure 3).

Innovative Process for Traditional Clothing

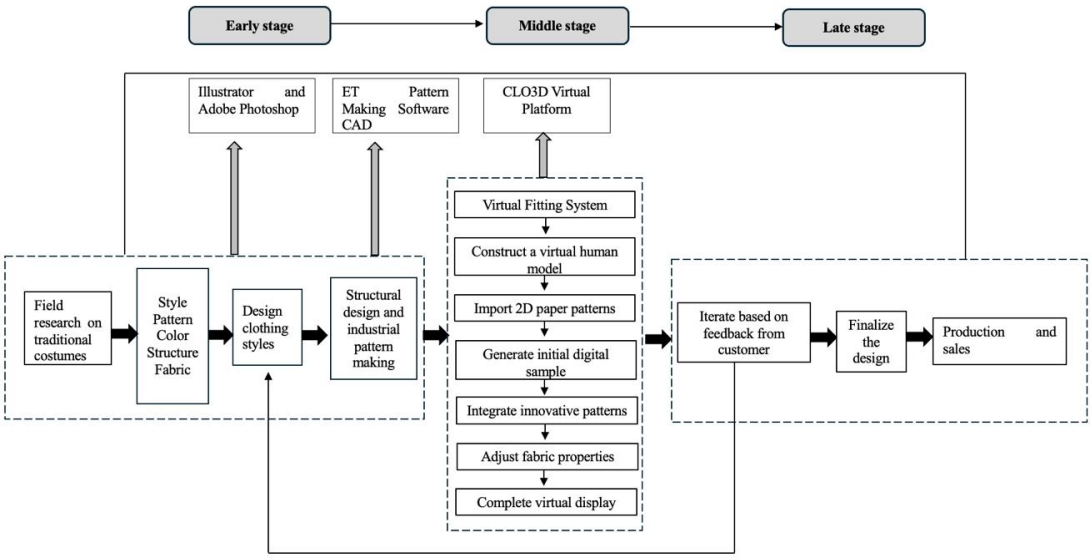

Figure 3. CLO3D's innovative design process for Yao ethnic costumes.

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Initial Phase: Preservation and Extraction of Cultural Attributes

The initial phase focused on preserving the integrity of Yao ethnic costume heritage. Through field research and digital tools such as Photoshop and Illustrator, the structural elements of traditional Yao costumes were analyzed. Patterns were digitized, segmented into their smallest units, and their characteristics were studied to create a comprehensive database of pattern elements. This approach effectively safeguards the Yao costume heritage from cultural erosion. By integrating traditional elements with contemporary design principles and market insights, innovative patterns, colors, and styles were developed that respect cultural values while appealing to modern consumers. Conduct a comprehensive analysis of traditional clothing's cultural attributes, extracting salient ethnic elements for innovative clothing design. Utilize ET software to generate 2D patterns.

Intermediate Phase: Enhanced Visualization and Design Capabilities

The intermediate phase demonstrated the significant advantages of CLO3D in enhancing visualization and design capabilities. In this phase, construct a virtual human model. Integrate 2D patterns into CLO3D to create initial digital garments, incorporating innovative design elements and fine-tuning fabric properties. The software's 3D modeling function allowed for precise representation of Yao costume patterns, styles, and structural details. Virtual displays enabled effective fit evaluation, reducing the need for physical samples. Compared to traditional methods, CLO3D's iterative design process, based on consumer feedback, minimized waste and inaccuracies. The software also reduced material consumption, labor costs, and design timelines, offering both flexibility and realistic visual effects. For example, the design cycle for complex styles was significantly shortened, allowing for rapid design verification and adaptation to evolving consumer preferences.

Terminal Phase: Accurate Representation and Consumer Validation

In the terminal phase, iteratively refine the design based on customer feedback, culminating in a production-ready garment. CLO3D accurately represented virtual Yao costume designs, enabling effective evaluation of fabrics, colors, and patterns. Consumer reviews validated the tool's utility for fit assessment and design experimentation. The iterative refinement process culminated in production-ready garments, demonstrating the software's ability to streamline the design process and enhance flexibility.

Key Advantages of CLO3D

The adoption of CLO3D for innovative traditional clothing design offers several advantages:

- Reduced material and labor costs: By minimizing the need for physical samples, CLO3D significantly reduces material waste and labor expenses.
- Shortened design cycle: The software's ability to simulate 3D wearing effects and adjust fabric properties in real-time accelerates the design process.
- Rapid design verification: Designers can quickly test and modify designs, ensuring they meet consumer preferences and market demands.
- Enhanced flexibility for modifications: CLO3D's flexible design environment allows for easy adjustments to clothing shape and fabric properties, such as hardness and drape.

Limitations

While CLO3D offers numerous benefits, the study acknowledges certain limitations. The software requires a learning curve, and its effectiveness depends on the designer's proficiency. Additionally, the accuracy of virtual representations may vary depending on the complexity of the design and the quality of input data.

Conclusions

This study highlights the transformative potential of CLO3D digital technology in the preservation and innovative design of traditional Yao ethnic clothing. By integrating traditional cultural elements with modern design tools, the research establishes a robust framework for the digital preservation and creative development of ethnic costumes. The key conclusions are as follows:

1.Preservation of Cultural Heritage: The initial phase successfully preserved the integrity of Yao ethnic costume heritage through digital tools, ensuring the protection of cultural elements from erosion.

2.Enhanced Design Efficiency: CLO3D significantly improved visualization, design flexibility, and efficiency, reducing material waste, labor costs, and design timelines compared to traditional methods.

3.Consumer-Centric Design: The iterative design process, supported by consumer feedback, ensured that the final designs met modern market demands while respecting traditional values.

4.Broader Implications: The findings provide a valuable reference for the digital preservation and innovative design of other ethnic costumes, promoting the evolution of traditional clothing in a contemporary context.

In conclusion, CLO3D digital technology is a powerful tool for protecting and innovating traditional Yao clothing design. Its virtual display capabilities offer new perspectives for ethnic fashion innovation, enhancing the feasibility of virtual design and contributing to the sustainable development of cultural heritage. This study underscores the importance of integrating digital tools with traditional knowledge to bridge the gap between cultural preservation and modern design practices.

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