# From visual to multisensory: how does intangible cultural heritage of traditional costume self-remodel in digital interactive environment?

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## Abstract

With the rapid development of digital technologies such as artificial intelligence, virtual reality, augmented reality, and 3D imaging, digitalization has become one of the primary cultural heritage protection and dissemination methods. Compared with other cultural relics, traditional costumes are vulnerable to environmental factors in storage. Therefore, protecting them in the digital environment and stimulating visitors' senses effectively is still an important project. Especially under the upsurge of the "digital future", avant-garde and artistic virtual products and technological innovations such as virtual fashion, 3D simulation displays, and virtual exhibition halls have brought new cognition and provided abundant means for the digital protection of traditional costumes. However, researchers have not paid enough attention to summarizing their narratives and expressions in the context of digital technology from a methodological perspective.

First, this paper analyses the concept of intangible cultural heritage and its digitalization from a documentation perspective, investigating research themes, technical means, and display modes in the digital production of traditional costume heritages. This part is a review and summary of the early stage of the research. Second, this study combined 5 typical practical cases in China, from the aspects of multimedia interactive participation, mobile interactive applications, digital museum display(virtual tour), gamification(skins) and digital costume collection to explore how organizations, museums and professionals can use digital technology to map information transmission with the audience's multi-senses, which will better authentic experience of traditional costumes. Finally, taking the life etiquette costume of the Ming and Qing Dynasties as the research object, this study discusses the technical path and development strategy of digital protection and constructs the overall framework of the database.

The results show that as a cross-disciplinary field, emerging digital technologies have broad application potential in protecting traditional costume cultural heritages, conducive to reproducing the new form of these finite objects and delivering rich intrinsic value. Meanwhile, in the interaction process, visitors have more opportunities to perceive the more profound charm of cultural heritages. The conclusion in theoretical and practical value can be used as a reference for other related cultural heritage fields in the digital background.

## Author keywords

digitalization of intangible cultural heritage; traditional costume; digital technology; multi-dimensional construction; innovative application; case studies

## Introduction

With the rapid innovation and application of digital technology, it has become an obvious trend to use computer graphics, virtual reality (VR), augmented reality (AR), computer animation and other technological means to present national intangible culture through digital storage, retrieval and display (Ch'ng, Cai, Leow, & Zhang, 2019; Yu & Cui, 2021). The protection and effective development of intangible cultural heritage, realizing all-round and three-dimensional digital information transmission, as well as multi-sensory interactive experiences such as sight, hearing, and touch, effectively broadens the path for inheritance and enhances social influence (Zhuang, 2021).

Costumes are an intuitive expression of national self-cultivation and spiritual outlook. Their unique beauty is also essential to sharing pleasure and artistic inspiration for creativity(Kang, Cassidy, Cassidy, & Li, 2015). Visitors can only view the restricted and protected collection of valuable old costumes and textiles through the windows using the old exhibition methods. With the popularity of human-computer interaction technology, three-dimensional virtual presentation, and the new mode of clothing culture propagation through mobile clients, more comprehensive sensory experiences are provided to the public (Jiang, Guo, & Ma, 2017; Martin & Mauriello, 2013). This has become an effective way to inherit and recreate costume culture. Scholars pay attention to the technical aspects of digital costumes and explore the possibility of virtual simulation in reproducing historical costumes(Jiang et al., 2017; Villarreal, 2020). Some studies have applied two-dimensional and three-dimensional software to create digital replicas of costumes from historical sources and to assess the similarity between historical prototypes and their replicas(Kang et al., 2015; Moskvin, Kuzmichev, & Moskvina, 2019). Liu's latest research results, with the help of CLO3D software to complete

the costume archaeology and digital restoration of the figures in the Tang Dynasty's paintings(Liu, Lu, et al., 2022; Liu, Wu, et al., 2022; C. Zhu et al., 2022). In conclusion, digitalizing historical costumes is a contemporary multidisciplinary research field combining cultural studies, science-based reconstruction methods, and virtual reality(Moskvin et al., 2019).

A unisensory interface stimulates only one sense, while a multi-sensory interface involves multiple senses (e.g., sight, hearing, touch) (Mishra, Shukla, Rana, & Dwivedi, 2021). Immersive technologies such as VR and AR are cutting-edge in providing users with unique multi-sensory digital experiences(Spence, Puccinelli, Grewal, & Roggeveen, 2014). China has carried out the digital transformation of cultural products based on the digitalization of museums but there is still a gap between the practice and exploration of digital fashion for traditional costumes and other collections (such as porcelain and bronze ware). The content of this paper is organized as follows. First, this study reviewed relevant concepts through literature reviews, such as the realization process and technical means of intangible cultural heritage digitization, and the contents and methods of digital protection for traditional costumes. Secondly, combined with five typical cases in China, we summarized the specific methods of reshaping traditional costume cultural heritage with digital means to improve users' sensory cognition. The third part introduced one of our ongoing research and its digital protection ideas and development strategies. Finally, the academic and practical implications are discussed.

## Intangible cultural heritage, traditional costume and digital protection

### The digitization of intangible cultural heritage (ICH)

UNESCO's 2003 Convention defines the concept of Intangible Cultural Heritage (ICH) and divides it into five categories (UNESCO, 2003). China has further divided ICH into ten categories(Chinese Cultural Studies Center, 2008). Some scholars have integrated and concluded according to the research needs. For example, Lv et al. proposed that ICH can be divided into three major modules: traditional performance, traditional skills and culture(Lv & Zhang, 2016). It is unreasonable to use the dualism of tangible and intangible as the criterion for dividing the material and intangible cultural heritage(Carboni & De Luca, 2016). Because ICH contains both tangible and intangible material and behavioral meanings.

Digitalization has become one of the main ways to protect and spread ICH. The digitalization of ICH is to transform, reproduce and restore the contents of ICH into a shareable and renewable form by using digital collection, storage, processing, display and dissemination technologies (Ma, Tu, & Xu, 2019; Wang, 2009). The ICH's digitalization in China has experienced three historical stages of " in database " (2005-2012), " being online " (2013-2016), and " in presence " (2017-present), and has formed digital feature forms, communication and user experiences(Quan, 2022; Wen & Zhao, 2022). According to the characteristic of dynamic and static, the digitalization of ICH can divide into three categories: dynamic art (oral tradition and performing art), static art (craft skill), and space-time art (festival ceremony)(Ma et al., 2019). An analytical framework should account for the range of visible and invisible objects under the constraint of a context-dependent action in a universe of symbolical and collective representations and enable the digital

processing of physical and immaterial levels (Fig. 1)(Carboni & De Luca, 2016; Ma et al., 2019; Staab & Studer, 2010).
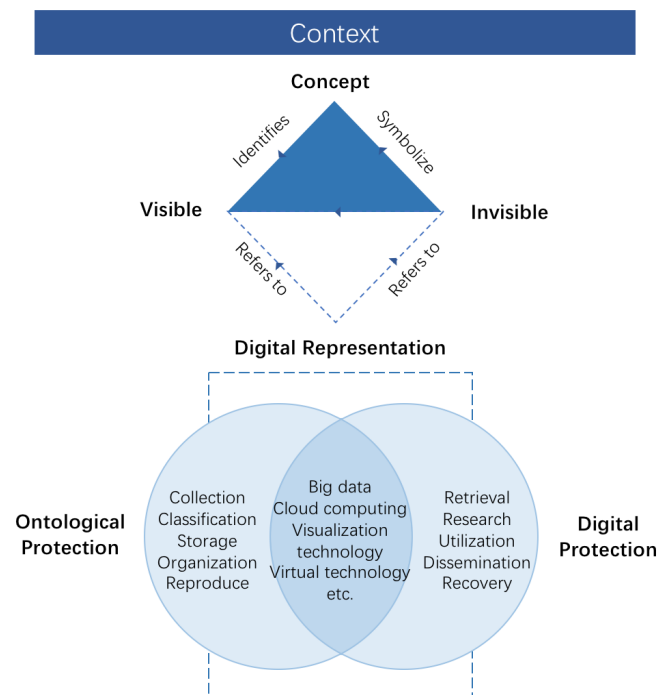


**Figure 1.** The process analysis and coding system construction of the digitization of ICH.

### The technical means and presentation methods of digital protection of ICH

Integrating cultural heritage and digital technologies has produced many concepts. Ma *et al.* (Ma *et al.*, 2019) differentiated ICH digital technologies between basic e.g., pictures, text, video, and audio, and emerging e.g., the application of 3D scanning, VR, AR, and motion capture technology, the latter providing more technical means to digitalizing ICH. Both technologies utilize various new media carriers to digitally display ICH. Some researchers have summarized and classified the exhibition types of ICH. For example, Huang *et al.*(Y. Huang & Tan, 2012) believed there are five presentations: traditional information type, mechanically controlled type, interactive touchscreen type, sensor-based interactive type and virtual-reality-based experiential type. In terms of the digital communication mode of ICH, mass media, digital collection, and Internet-based are the main modes of communication at present, with immersion communication as a supplement to the previous three(Tan & He, 2021). ICH encompasses a variety of types, cultural connotations, and categories. Therefore, digital displays need to adopt appropriate and varied media technologies in order to accurately display information about cultural relics and convey their intangible elements such as value and spiritual connotation (Ma *et al.*, 2019).

### The contents and presentation of digital protection of traditional costumes

Traditional costume collections found in handicraft and folk art are an important ICH and reflect a culture's social life. Cui et al. (Cui, Niu, & Wang, 2019) pointed out that traditional costume as a cultural expression can be seen in three contexts: material, social, and spiritual. Based on these contexts, our research constructed an overall framework of digital display

design of traditional costumes (Fig. 2). The flexible use of digital technology improves the effectiveness of the transmission of information about traditional costumes and enhances the audience's knowledge, viewing experience, and sensory perception of that interaction.

The traditional costume should focus on the organic combination of ontological and digital protection. To date, the ontological protection has been quite adequate. The digital protection of traditional costumes should focus on the dynamic presentation of invisible factors, such as traditional skills, the production process, and various attributes of cultural value and spiritual connotation. The display media for digital protection of traditional costumes are based mainly on public culture platforms, PC network platforms, mobile intelligent devices, and social networks (X. Zhang, 2015). For example, digital museums and digital databases, as necessary digital operating forms, are also introduced into the clothing field. Research has been conducted on making and restoring traditional Chinese clothing with 3D virtual technology, such as CLO3D, Style 3D and Style Fabric (Liu, Lu, et al., 2022; Tong & Li, 2021; W. Zhang & Ma, 2021). VR technology is essential for both revitalizing intangible values of ICH and comprehending those intangible values. It also allows for the understanding and reproduction of the relationship between tangible and intangible values in each context (Karakul, 2022).
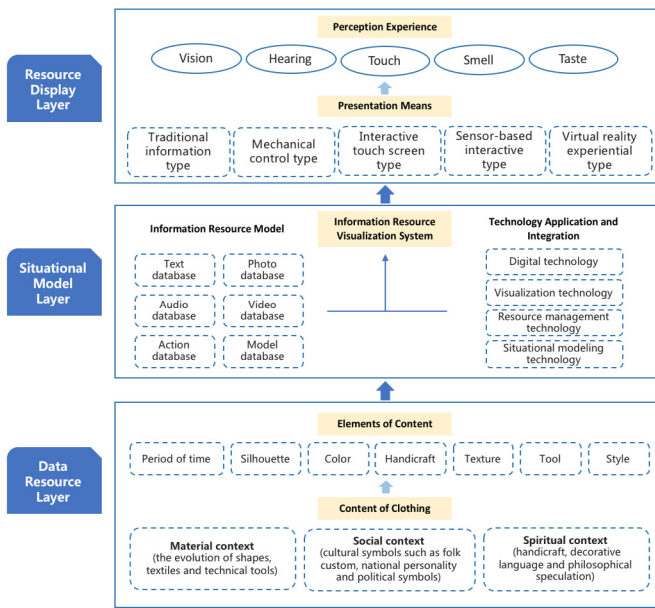


**Figure 2.** The model of digital display design of traditional costumes.

## Innovative application of digital protection of traditional costumes: Methods and case studies

### Case 1: "Palace Embroidery and Costume" project in the Palace Museum

In addition to using traditional media to display intangible cultural heritage, museums, art galleries, and other public cultural platforms integrate digital means for display(X. Zhang, 2015). The Duanmen Digital Pavilion is composed of the virtual digital form of the Palace Museum's cultural relics, including paintings, interior furnishings, costumes, embroideries, ancient architecture and so forth(M. Huang, 2016). Using the interactive display of "Digital Court Costumes" with human

posture recognition technology and Kinect motion-sensing control technology, visitors can virtually try on Qing Dynasty court costumes through interactive equipment (Fig. 3). This interactive feature allows users to appreciate and understand their artistic features and institutional norms, thus deepening their knowledge of traditional costume culture. In the "Digital Palace Embroidery Paintings" project, visitors can use touch screen linkage Ventuz technology to gain an understanding of the imperial embroidery painting process and to observe traditional skills such as embroidery. In conclusion, interactive multimedia, with its sensory participation experience, is the platform whereby visitors more easily understand the historical aspects of cultural relics collections.

### Case 2: Ethnic Costumes Museum of Beijing Institute of Fashion Technology

Major comprehensive museums or museums focusing on costume collections have realized the importance of building a web-based digital museum with the Internet and digital technology for online communication, dissemination and protection of intangible cultural heritage(Wu, Jiang, Liang, & Ni, 2022). The Ethnic Costumes Museum of the Beijing Institute of Fashion Technology holds more than 10,000 pieces of traditional cultural relics, such as national costumes, fabrics, embroideries and silver ornaments(Beijing Institute of Fashion Technology). The Museum has a digital database of ethnic costumes based on design and application, thus providing an opportunity for researchers and lovers of costume culture to gain a greater understanding of the subject. The Museum's Ethnic Costume database displays the clothing of 36 ethnic groups in China. Among these, the Han costume section includes 291 pieces of short jackets, long gowns, single trousers, horse-face skirts (Fig. 4), and cloud shoulders. Each collection piece has detailed descriptions (basic properties, collection information, material technology) and pictures (overall silhouettes, details, cutting drawings). Using short videos and animations, the Museum's three other databases display 32 pieces from ancient collections, introduce 91 typical costume materials and techniques, and show the
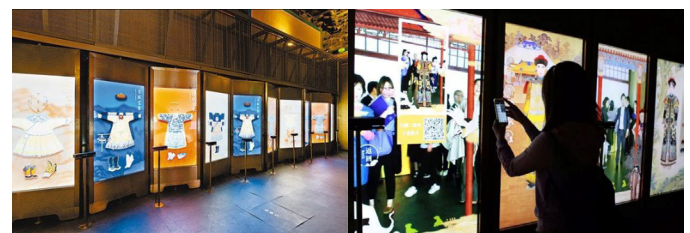


**Figure 3.** The digital project of the Palace Costumes.



**Figure 4.** The display online of digital database for ethnic costumes.

production details and wearing process. The digitalization of the Ethnic Costume Museum has broadened online access to valuable resources, thus enabling historical costume lovers and researchers to further their learning and stimulate their positive attitude toward cultural heritage.

## Case 3: The art visualization network platform of Guizhou ethnic minorities

Taking the excellent traditional culture and art of 17 ethnic minorities in Guizhou who have lived for generations as the research object, this project classified and displayed them in digital ways by integrating internet information technology and big data(Guizhou Minzu University). Four mobile apps have been built with AR interactive displays and interactive wearable experiences to allow users to view ethnic costumes, silver jewellery, architecture and opera. When opening the "Guizhou costume" program (Fig. 5), users can select the representative costume through the left and right arrows and understand its basic shape and patterns by rotating the 3D model. In addition, app users can learn the cultural connotation of the traditional costume by reading the accompanying text description when they click the model. Interestingly, AR technology can be used to create a virtual scene with interactive characteristics by first scanning the ground and then combining costumes, characters, and scenes in a self-selected background. This, too, is available just with a click, on the circular icon in the upper left corner of the home page. This process helps users obtain a more comprehensive sensory experience of traditional costumes (Fig. 5). This project also built a virtual simulation platform of Miao embroidery, where visitors can learn Miao embroidery skills at any time by following an on-screen step-by-step animation simulation. Therefore, the interactive experience of the AR interface can help users better imagine what these historical costumes may have looked like, thus increasing their enthusiasm for learning traditional costumes.



**Figure 5.** 3D model and AR experience of the Miao nationality's costume for the festival.



**Figure 6.** The design of the traditional costume game skin in The Magic Blade.

## Case 4: The series of digital costume design in Liangyuan Hanfu and Huaxia Nishang

Digital costumes are commonly known as skins in the game industry. Skins are one of the tools used by players to decorate their avatar to achieve a unique and personalized aesthetic expression of the player, rather than just a simple graphic symbol(Makryniotis, 2018). Louis Vuitton, Burberry, and other luxury brands have cooperated with game companies to design costumes for game characters and produce gamified digital marketing. Currently, historical costume elements are also introduced into digital fashion to promote the sustainable development of traditional costume culture. In 2021, the TV program "Dress China" cooperated with the designer, Guo Pei, and the game "The Magic Blade", leading to the design of a series of Chinese-style costumes in the theme, "Floral Scrolls with Mandarin Duck". This pattern represents the beauty of good marriage (Fig. 6). These costumes are reproduced by digital art, so young people can enhance their perception of the beauty of Chinese-style costumes when playing games. Gamification is a design strategy that improves users' experience. Fu *et.al*(Fu & Liang, 2022) said traditional costume skins could build emotional bonds between game users and game characters, stimulating players' curiosity, imagination and exploration and enhancing their cultural identity in the real world and well-being in the virtual world. Museums and costume-oriented cultural organizations have also formed a new creative mode that can be shared(Wen & Zhao, 2022). In 2022, the magazine, Chinese fashion, and the digital collection platform, Changong, launched a series of digital traditional costume collections of "HuaXia Nishang" from the Tang, Song, Ming, and Qing Dynasties in which users can virtually try on costumes(Qing, 2022). Overall, the combination of online games and traditional costumes can be seen as an attempt to lead modern fashion consumption and the sustainable development of traditional Chinese costumes in a digital way.

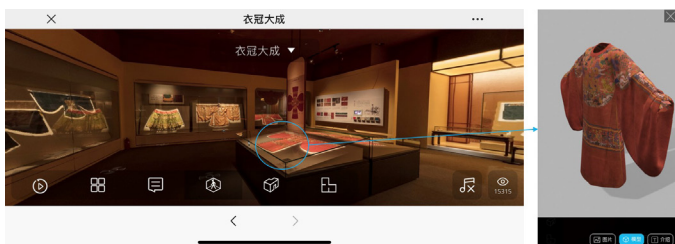**Figure 7.** Costume interactive program through a visitor touch screen.



**Figure 8.** The virtual exhibition hall of the "Yiguan Dacheng: The Costume Culture Exhibition of Ming Dynasty" and 3D virtual costume models.

## Case 5: Digital preservation and utilization project of relics collected by Shandong Museum

Clothing from the Confucius Mansion is the symbol of the Ming Dynasty costume culture and, as a result, is rich in information about the Dynasty's intangible elements and hierarchy regulations. In 2022, one important part of the "Digital preservation and utilization project of relics collected by Shandong Museum" was "Yiguan Dacheng: The Costume Culture Exhibition of Ming Dynasty". This undertaking digitally protected more than 40 pieces or sets of historical costumes which have been collected by Shandong Museum, spanning a range of silhouettes, details, and textiles. This project consists of three steps: high-definition photo shooting; three-dimensional data acquisition and processing; and, pattern extraction(Z. Zhu & Zhou, 2020). Information mapping, the most crucial aspect of digital protection, maps the detailed structure and color texture collected by the HD camera in the first step to the modeling results from the second step. The result is a three-dimensional model with complete information. This project differs from the other project's noted above because its displays are comprehensive and use a variety of technical means and display media for representation and communication. For example, the large-screen interactive program set up in the physical museum (Fig. 7) can present costume information through a visitor touch screen. The exhibition also designed a touch screen version of silk fabric to enhance tactile perception(An & Chen, 2022). Additionally, there is an animated display showing when and how traditional costumes were worn by those living in the Confucius Family Mansion. The animation enhances the audience's visual and auditory senses, leading to a deeper understanding of the meaning of each traditional costume. Elsewhere, visitors can experience a virtual tour of the virtual exhibition hall(Fig. 8). More interestingly, visitors can click the costume picture to watch the high-definition 3D virtual costume model and learn about the costume's pattern, wearing rules, and meaning. In summary, this project uses digital deduction and engaging interactive experiences to entertain visitors and advance their aesthetic perception and knowledge.
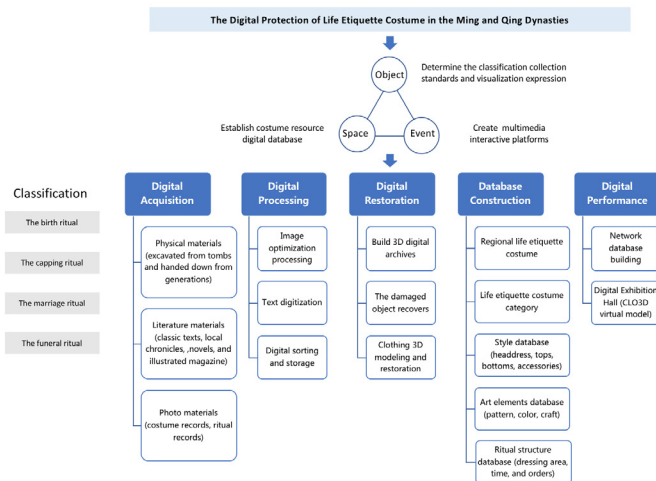


**Figure 9.** Digital protection countermeasures of life etiquette costume in the Ming and Qing dynasties

## Exploration on the path of the digital protection of traditional costumes: Taking the Life Etiquette Costume in Ming and Qing Dynasties as an example

Life etiquette is a vital yet intangible part of folk culture heritage, constituting a symbolic cultural space created from folk costumes, rites, rituals, and beliefs. It is generally believed that the four transitional rites held at the critical point of life stage of birth, adulthood, marriage and death are called "life etiquette", which is an important "rites of passage"(from Arnold van Gennep(Gennep, Vizedon, & Caffee, 1961), French ethnographer and folklorist). A person's life etiquette costume is the clothes they wear during the four critical stages of life (birth, adulthood, marriage and death). As carriers of ritual activities, life etiquette costumes play an important cultural intermediary role. They contain rich artistic aesthetics, folk connotations and cultural characteristics. Changes in social environments, norms, and rituals, have led to the disappearance of the rituals and costumes that represent traditional life etiquette. In the complex and multiple modern context, especially the era background when the government emphasizes the importance of strengthening national etiquette education in China, the contemporary inheritance and practical transformation of traditional life etiquette costumes have attracted the attention of many aspects. The use of digital technology in the information age may give life etiquette costume "new life" and provide strong support for the dissemination, protection and development of traditional clothing cultural resources. Therefore, this study proposes a path for the digital protection of life etiquette and costume culture in the Ming and Qing Dynasties through the use of "object (costume)", "event (narration)", and "space (experience)" (Fig. 9). Before building the database, digital acquisition (e.g., literature and images), digital processing (e.g., image optimization) and digital restoration (virtual restoration and multidimensional display) are necessary for life etiquette costumes. The overall framework of the database classifies and sorts the corresponding life etiquette costumes according to the life etiquette categories and ritual structure and then summarizes the primary sorts, typical styles and collocation ways in the dressing lines. Hopefully, this approach of presenting the results of both the literature review and research on life etiquette costumes will provide a model for contemporary dress codes and design guidelines.

## Discussion and conclusion

A field of research is currently exploring how best to effectively combine intangible cultural heritage with emerging digital technologies so that user interactions are optimized. A summary of the results are as follows:

1   This study contributes to the literature on the application of digital technology in the digital conservation of ICH and traditional costume relics and the role of providing a multisensory user experience. This study summarized the basic concepts, primary technical means, and presentation media of intangible cultural heritage digitization through literature reviews. Compared with unisensory interfaces, multisensory interfaces provide vividness and interactivity for users in a sensory-rich environment(Flavián, Ibáñez-Sánchez, & Orús, 2019). Based on this, from the perspective of costume culture communication, this study built an overall framework for the digital display design of traditional costumes. The application of digital technologies (such as AR, VR and 3D virtual) expands traditional displays. It visualizes the projection of the real world and the physical environment, promoting information search and reducing the cognitive burden of users.

**Table 1.** Overview of innovative application cases of digital protection of traditional costumes.

| NO. | Title of the case | Display media | Display mode |
|---|---|---|---|
| Case 1 | "Palace Embroidery and Costume" pro-ject in the Palace Museum | Public culture platforms | Multimedia interactive application |
| Case 2 | Ethnic Costumes Museum of Beijing Institute of Fashion Technology | PC network platforms | Digital image presentation |
| Case 3 | The art visualization network platform of Guizhou ethnic minorities | Mobile intelligent de-vices | AR interaction scene construction |
| Case 4 | The series of digital costume design in Liangyuan Hanfu and Huaxia Nishang | Social networks | Gamification design and development, network media display |
| Case 5 | Digital preservation and utilization project of relics collected by Shandong Museum | Public culture plat-forms, PC network platforms, mobile intelligent devices and social networks | Network media display, 3D virtual simulation, multimedia interactive application, digital animation innovation |

2   This study selects 5 typical cases to explore methods of traditional costume relics' digital protection and their adapted digital media and modes (Table 1). The research shows that the digital communication mode based on public culture and PC network platforms is the most common way to promote knowledge learning and sensory attraction. Creating AR interactive scenes changed the costume display for users, effectively improving users' interest and visual perception. Integrating traditional costume elements into gamification design and digital collections will become new tools for museums and cultural institutions to expand the spread of costume culture. Case 5 shows a relatively comprehensive digital communication system for the intangible cultural heritage of a costume. Dynamic forms of multiple senses can create higher visual and emotional attraction to enhance the interactive experience and improve users' cognition and understanding of costume culture.

3   Taking the life etiquette costume of the Ming and Qing Dynasties as the research object, this study discusses the technical path and development strategy of digital protection and constructs the overall framework of the database from the direction of "object-event-space". The communication of traditional costumes needs to include the activity field matching them. Computer graphics technology and 3D clothing software provide the opportunity to realize the image, product and space virtualization of traditional costumes and improve users' perceived visual and emotional attraction to a greater extent. More importantly, digital practice is beneficial to the protection and promotion of life etiquette costume, such as promoting understanding and acceptance of traditional culture or fostering national pride in younger generations and providing inspiration for relevant designers or enterprises in product design.

Digital design content is regarded as the expression of technology, but it is worth paying attention to how to use technology to design and establish effective information dissemination channels. Through the analysis of typical cases, the results of this study aim to help museum managers, organizers and designers better understand the application status of intangible cultural heritage digitization and provide valuable strategic insights into the development, application and promotion of the multisensory interface experience of traditional costumes extended by digital technology. Further studies should adopt quantitative research to compare users' responses to the digitalization of costumes between haptic and multisensory interfaces. Additionally, the role of different levels of users' attitudes and behavioral intentions in a multisensory environment should be explored.

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