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Historical changes of Chinese costumes from the perspective of archaeology

Kaixuan Liu*, Shunmuzi Zhou and Chun Zhu

Abstract

Garments are an important product in the history of human development. With the development of human history, there is also a constant reform and evolution of garments. As the bearer of historical culture in each period, the changes in the shape and production process of costume are the result of the continuous evolution of Chinese costume culture. Nowadays, historical artifacts from various dynasties are continuously unearthed, which are of great value for the study of ancient costumes. From the perspective of garment engineering and archaeology, this paper analyzes the representative costume-related artifacts of each dynasty, and through the understanding of the costume history and culture of each dynasty, 3D digital restoration of the costumes is carried out based on virtual fitting technology to show the more complete development of ancient costumes. It has a certain reference value for the study of the historical changes of ancient Chinese costumes, and it is also helpful for the preservation of ancient Chinese costumes and the promotion of ancient Chinese costume culture.

Keywords: Chinese dynasties, Ancient costume history, Virtual costumes, Cultural heritage, 3D reconstruction of historical costumes

Introduction

With a history of 5000 years, China is extremely rich in culture. As an ancient civilization with a thousand-year history, China has raised countless Chinese descendants and experienced the change of many dynasties, and the products left behind in this long history are the bearers of Chinese civilization. The history of Chinese costumes is also a road of cultural changes worn on the body.

As a major costume country, the traditional costumes of all Chinese dynasties are a precious material cultural heritage of Chinese history, a witness to the historical and cultural changes in China over the past 5000 years, and a record of the historical changes and cultural development of ancient society. The costumes of the Chinese dynasties also reflect the ideology, culture, customs, artistic beliefs, aesthetics and other information of the dynasties in which they were worn, making a great contribution to

the development and changes of Chinese culture and the study of Chinese history and culture.

With the continuous advancement of archaeology in China, historical relics once buried in the earth have finally reappeared, conveying the culture, customs and life of the ancient people to the world. It has also provided a large number of cultural relics for the study of ancient traditional costumes in China and promoted the research of scholars in this area. The research materials of ancient costumes mainly include unearthed wooden figurines, terracotta figurines, paintings on silk, portraits, murals, real costume and other cultural relics related to the costumes of that dynasty. The study of representative costumes selected from these unearthed cultural relics will help to learn about the history and costume cultural of each dynasty in China.

Nowadays, research on the protection of traditional costume is very important. Except for Qing dynasty (1636 AD-1912AD) costumes, which are mostly preserved intact, costumes of other long-established dynasties are very rare, and most of the unearthed ancient costumes

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have lost their original colors, and the costumes are fragmented and incomplete. Therefore, it is very necessary to study ancient costumes through ancient costume related artifacts. Ancient costume related artifacts are the physical evidence of ancient costume and an important material for studying ancient culture. The archaeological study of ancient costume related relics, using digital technology to show the history of ancient costume changes, is more convenient and intuitive to show the original appearance of ancient costumes, and to promote and spread the ancient Chinese traditional culture.

With the advancement of technology, combining traditional culture with technology is currently a proven method for cultural preservation, and digital technology provides a feasible technical mean for traditional culture preservation [1, 2], including the establishment of a digital repository of traditional culture [3], the digital display of cultural heritage [4, 5], the application of digital archaeology [6, 7], digital restoration and reconstruction of cultural relics [8, 9], digital modeling and innovative design of Chinese traditional opera costumes [10, 11], etc.

Currently, the development of 3D digital technology for costumes has gradually matured. Compared with traditional restoration technology, the 3D digital technology not only saves time and cost, but also reduces the difficulty of costume restoration [12, 13]. Combining the protection and inheritance of traditional costume culture with modern technology is a necessary trend for current development. At the same time, the virtual reconstruction of costume relics in the past dynasties transforms the flat, incomplete costumes into stereoscopic, complete, 3D costumes that can be observed in detail, which is of great significance to the current education of Chinese costumes history. The 3D display of costumes can also show learners the details of costume structure, patterns and fabrics at anytime and anywhere, deepening learners' understanding and comprehension of traditional Chinese costumes.

3D digital technology has been gradually researched with the progress of the times, and its application areas are extensive. Currently, many scholars have researched on digital technology of costumes, including apparel virtual simulation and display [14–16], apparel interaction design [17–19], garment fit evaluation [20–22] and virtual try-on [23, 24]. These studies prove that it is feasible to restore traditional costumes by 3D digital technology. Virtual reality technology plays a crucial role in the digital preservation of traditional cultural heritage. The virtualization of historical artifacts for display is a current research fever. Desheng Lyu et al. [25] used simulation technology to virtualize the female costumes of the Tang dynasty (618 AD–907 AD) and built a virtual display

system. Shang Shuyuan et al. [26] established a virtual costume museum based on the museum of Beijing Institute of Fashion Technology and its collection of exhibits. Martijn A. Wijnhoven et al. [27] have reconstructed the Vimose mail armor of 150 AD–220 AD period in the collection of the National Museum in Copenhagen. Aleksei Moskvina et al. [28] used archaeological information and other resources to combine a variety of virtual reconstruction software to restore German soldier's costumes from the 2nd to fourth centuries AD. Wang xu et al. [29] used CLO 3D software to restore Qing dynasty dragon robes, and verified the feasibility of the digital inheritance of Qing dynasty dragon robes. In terms of research on the virtual restoration of historical costumes, Liu Kaixuan et al. [30] used virtual simulation technology to digitize Tang dynasty costumes in "*DaoLian Painting* (《捣练图》)" to realize the preservation and dissemination of Tang dynasty costumes. They also realized the study and preservation of historical costumes by analyzing the costume forms on "*Han Xizai's Banquet Painting* (《韩熙载夜宴图》)" [31], "*Spring Outing Painting of Madam Guo* (《虢国夫人游春图》)" [32], Tang dynasty tomb murals [12], Mawangdui Han dynasty tomb [13] respectively. Yang yuqing et al. [33] used CLO 3D to recover the costume worn by Song dynasty empress "Hui Yi (惠仪)" by looking at her portrait. Aleksei Moskvina et al. [34] restored the historic skirt based on a photograph of a woman wearing an 1860s skirt with data related to costumes from the period. Victor Kuzmichev et al. [35] have created a virtual reconstruction of a late Victorian riding skirt based on three 1887 pictures of a woman riding a horse. Victor Kuzmichev et al. [36] have made a virtual reconstruction of the men's suit from a painting by Sir William Charles Ross of Prince Albert of the Saxe-Coburg and Gotha. In summary, we can use virtual simulation technology to virtually reconstruct traditional costumes of Chinese dynasties through the representative costume-related cultural relics of each dynasty, such as murals, terracotta figurines, portraits, and traditional costumes, etc.

China has a long history and has experienced dynastic changes and produced countless civilizations. Combining traditional costume culture with modern technology to achieve the preservation of traditional costumes of each dynasty. In this paper, it is to study the costumes of various ancient Chinese dynasties from the perspective of garment engineering and archaeology. Since some dynasties have a long history and their related costume physical materials are less, so now we will study the pattern, style and structure of the costume based on the interpretation of the collected representative portraits and costume materials of each dynasty. The costumes will be virtually reconstructed, and the traditional costumes in

archaeological relics will be transformed into 3D digital costumes for display. The research shows the historical changes of ancient Chinese costume through 3D virtual simulation, further realizing the conservation and dissemination of traditional costumes.

Method

Technology roadmap

The technical roadmap of this article is shown in Fig. 1. The 3D digital recovery of ancient Chinese costumes is based on the most representative archaeological relics of each dynasty. Through the collection of costume materials and archaeological documents in China's past dynasties, we study the style, pattern and fabric composition of costume relics. Then we draw the style of Chinese costumes of previous dynasties. According to the style, we make costume patterns of previous dynasties. Finally, we carry out a 3D digital restoration of Chinese costumes according to the costume patterns.

Analysis of ancient Chinese costumes

Analysis of ancient Chinese costume styles

China is a large country with countless styles of costume. Traditional Chinese costume styles have been changing with dynasties. Different dynasties have different costume styles. In order to better study the historical changes of Chinese costumes, we introduce the most basic and characteristic costume styles of each dynasty, see Fig. 2.

The traditional Chinese dress form has been precipitated for thousands of years and gradually formed two forms: the top coat-plus-skirt, and the top and bottom connected. During the Xia (夏), Shang (商) and Zhou (周) Dynasties, the earliest feudal dynasties in ancient China, the function of costumes was not only to keep warm and decorate, but also to symbolize the status of class. The main form of costumes in the Xia, Shang and Zhou periods was the top coat-plus-skirt form (上衣下裳).

During the Chunqiu (春秋) period (770-476 BC) and Zhanguo (战国) period (477 BC-221 BC), due to

the frequent wars, the cultures of various regions kept intermingling. The costumes in this social environment also kept exchanging and evolving. The most representative costumes in this period are: Shen yi (深衣) and Hufu (胡服). Shen yi appeared in this period, also prevailed in this period, and had influence on the costume of the following dynasties. The emergence of the Hufu was due to the fact that King Wuling Zhao was inspired by the short clothes and long pants form of minority costumes for the convenience of combat, which was a major change in the history of Chinese costumes.

During the Qin dynasty (221 BC-207 BC) and Han dynasty (202 BC-220 AD), after the unification of the six states in Qin dynasty, due to only 15 years of rule, Qin dynasty did not have major changes in costume, but continued the basic shape of costume in the Chunqiu period. The costume of the Qin and Han dynasties still take Shen yi system robe as the typical costume style, divided into two kinds of Quju (曲裾) and Zhiju (直裾). In addition, the typical costumes of Han dynasty also included Ru (襦), pants and skirt. Ru (襦) could be worn by both men and women, while Pants were worn by men and skirts worn by women. The form of Han dynasty costumes was presented with a short upper matched with a separated bottom.

During the Wei, Jin, North and South Dynasties (220 AD-589 AD), due to social unrest and cultural fusion among various ethnic groups, costumes also underwent significant changes. In the Wei and Jin dynasties, costumes were still based on Shan (衫), Ru and skirt. The large sleeved gown was prevalent for a while. With the integration of ethnic minorities and Han culture, costumes of all ethnic groups had influenced each other. Kuxi (裤褶) and Liangdang (裲裆) were the emergence of a more classic style of costume at that time. Kuxi are in the form of upper and lower pants, which can be worn directly outside. Liangdang consists of front and back pieces of costume, later called the vest. Zajuchuishao (杂裾垂髻服) with sharp corners on both sides

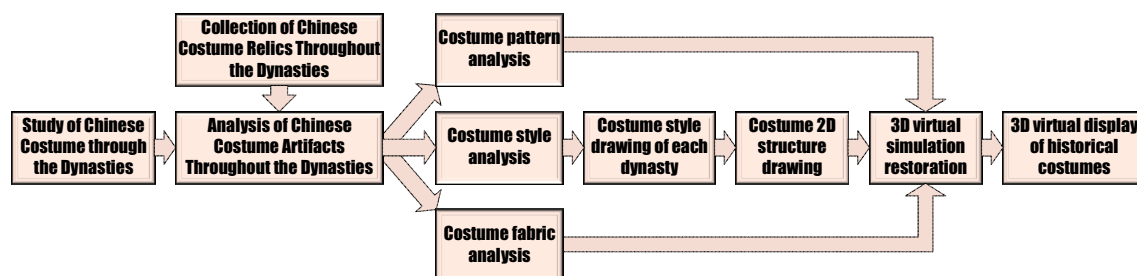


Fig. 1 Technology roadmap

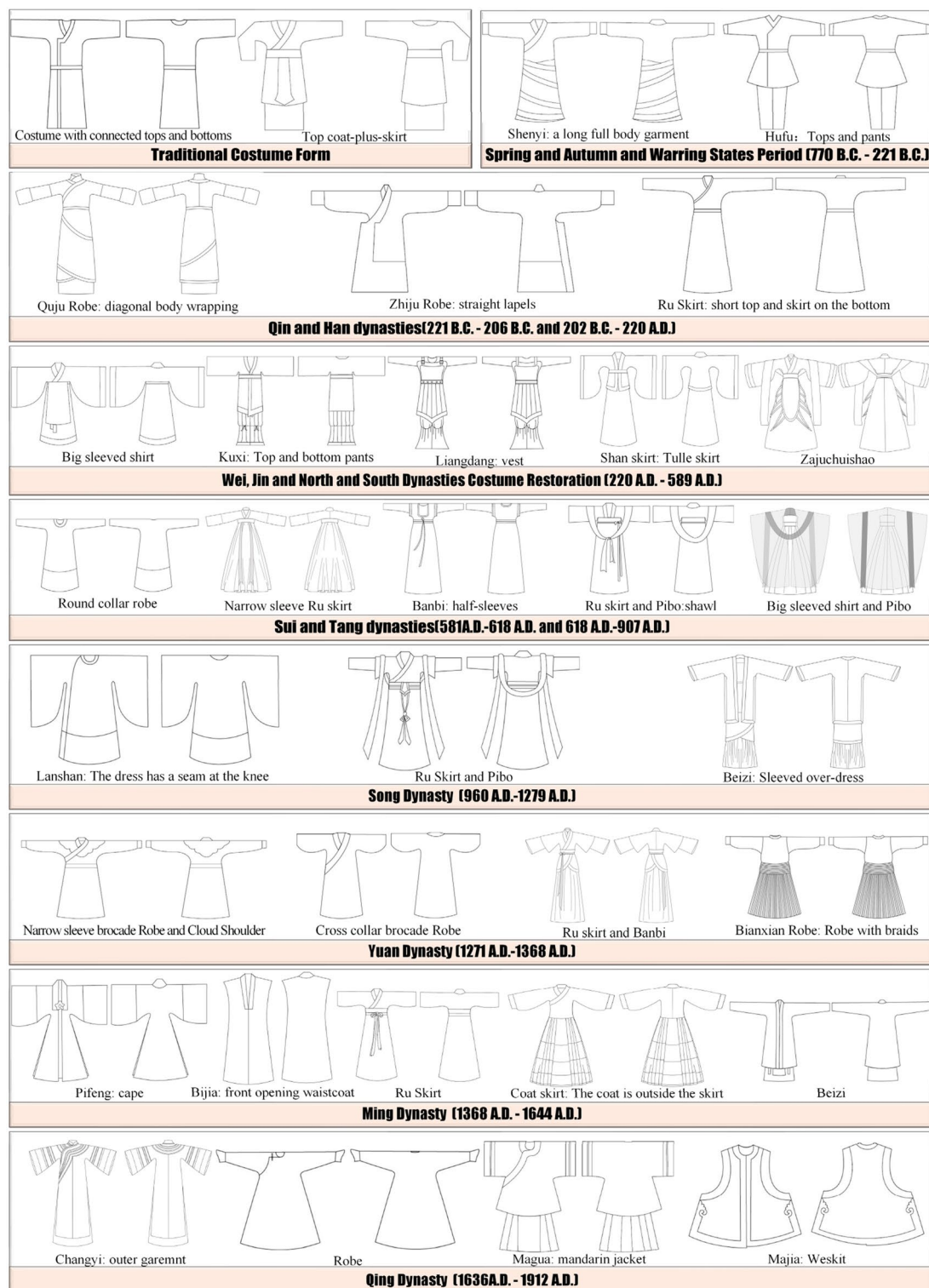


Fig. 2 Chinese costume styles of the past dynasties

appeared in this period is a women's dress, which is a more representative costume.

During the Sui (581 AD-618 AD), Tang (618 AD-907 AD) and Five Dynasties (907 AD-960 AD) periods, Sui costumes were influenced by minority dress styles, and the costumes were mostly small-sleeved and high-waisted skirts. The Tang dynasty was the most economically prosperous and culturally open and integrated dynasty in the feudal period of China. Early Tang women's costumes were still narrow and small. In the middle of the Tang dynasty after the influence of minority dress style gradually weakened, and women's costumes became wider. The basic form of women's costumes in the Tang dynasty was the upper garment: Shan, Ru, coat, Pibo (帔帛), often with a half sleeve, while the lower garment: skirt. The general form of men's costumes was the upper garment: robe, Ru, Shan, coat and half-sleeves, while the lower garment: skirt and pants.

Song dynasty (960 AD-1279 AD) costumes generally followed the old system of Sui and Tang Dynasties, but with more restraint and rigor. The costumes of Song dynasty were simple and plain. Men and women are especially fond of wearing Beizi (褙子). Beizi became the most characteristic costume of the Song dynasty. Song dynasty women's tops were mainly Shan, short Ru, Beizi, and tube top, with skirts and pants at the bottom. The form of men's costumes mainly consisted of robe, Ru, coat, Shan and Beizi.

Yuan dynasty (1271 AD-1368 AD) was founded by the Mongols. The main costume of the Yuan dynasty was "Zhisun Costume" (质孙服), which meant that the whole body was dressed in one color. The overall costume was very monotonous. There was no unified dress system in the Yuan dynasty, so the common people wore Chinese costumes. For example, women wore Ru skirts. The dress forms of the Yuan dynasty were: robe, Shan, Ru, etc. Bianxian Coats (辫线袄) were more popular in that period.

After the establishment of the Ming dynasty (1368 AD-1644 AD), the government started to ban Hufu and began to restore Han costume system. The main form of women's costume in the Ming dynasty is the Shan and skirt, coat, Bijia (比甲) and Beizi, etc. Men were mainly in robe and Shan. The traditional Chinese horse-face skirt also originated in the Ming dynasty. The skirt has a total of four skirt doors in the front and back, inside and outside, with the inner and outer skirt doors overlapping each other and the front and back being symmetrical.

The Qing dynasty was a period of intermingling of Manchu and Han cultures. The rulers of the Qing dynasty forced the Han Chinese to change their hairstyles and costumes, which made great changes in ancient Chinese costumes in this last feudal dynasty. The costumes of the

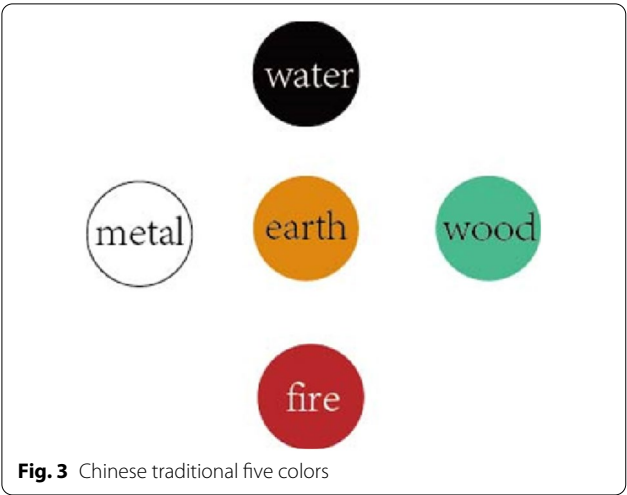
Qing Dynasty are different from the wide robe and large sleeve of the Han nationality, but it is narrow sleeve and gown. The civilian Han women's costumes in the Qing dynasty can also bear the Han costume system, the upper body was coat and Shan, and the lower body was mainly a skirt. Manchu women generally wear Manchu attire. Men must shave their hair to change their costumes, their costumes includes robe, Shan, Ma Gua (马褂), coat, etc.

Analysis of ancient Chinese costume colors, patterns and fabrics

The history of changes in ancient costumes is also the history of the progress of the Chinese textile industry. With the continuous progress of the textile industry, the colors, patterns and fabrics of Chinese costumes in each dynasty also changed. At the same time, due to the continuous development and change of culture, the ideas, culture and customs popularized by each dynasty also changed, and the symbolic meaning of the patterns and colors of the costumes also changed.

From the use of bone needle sewing animal skins to make abbreviated costumes, to the use of hemp fiber woven into fabric, raising silkworms spinning silk, China's clothing fabric textile technology gradually improved, and the textile fabric became exquisite. China is a large silk country. Although there have been a few silkworm fabrics since the Xia Dynasty, most of the costume fabrics are hemp. After the Shang dynasty, silk fabrics began to occupy an important position. Due to the continuous development of Chinese textile technology, various warp and weft knitting organization structure, materials, different textile technology, silk fabrics can be divided into yarn, crepe, Luo (罗), Qi (绮), satin, etc. Cotton fabrics became popular and spread in the Song and Yuan dynasties, before that China's fabrics have been mainly silk, hemp, leather, wool. Due to the good performance of cotton and the increasing production, good quality and low price, its application in the field of clothing gradually occupies a dominant position.

Chinese costume colors also have class symbolism. Due to the worship of natural forces, the Chinese five colors are said to come from the five elements, namely: metal, water, wood, fire and earth, which correspond to the traditional Chinese pure five colors: white, black, cyan, red and yellow, see Fig. 3. Yellow, as the middle, is the dominant and most noble. Later, yellow became the official royal color during the Tang dynasty. Throughout the historical changes in Chinese costumes, with some archaeological scientific empirical evidence and ancient books, it can be unearthed that the costume colors in each period changed with the beliefs of the dynasties and the esteem of the emperors. During the Xia, Shang and Zhou



dynasties, costumes' colors were mostly red and yellow because they were mostly dyed by mineral dyes. Later, as the technology of textile printing and dyeing improved, the costume colors became richer and richer.

The traditional Chinese colors, mainly the pure five colors, laid the foundation of Chinese dress colors, see Fig. 4. The Zhou dynasty revered the color red, while the Qin dynasty (221 BC-207 BC) defeated the Zhou dynasty and took water as a virtue, and its clothing revered black, followed by red, green, yellow and white colors. Because of the class symbolism of color, folk costumes of the Qin dynasty could only wear secondary color and compound color costumes. The color of Han dynasty costumes revered dark colors, including black, red, etc., while folk people could only use compound colors, such as: brown, gray, etc. The Wei, Jin, North and South Dynasties were socially turbulent, and the development of their costumes would also be affected by the rich colors, but they were

relatively more monotonous. The Tang dynasty was the most prosperous feudal dynasty in China, at this time the economy was developed, the society was prosperous, the dress style was gorgeous, the most popular colors in the Tang dynasty were red, dark reddish purple, yellow-green, etc. The Song dynasty advocated frugality and eliminated luxury, and people were influenced by this concept at that time, and the style of dress was plainer and more elegant, with popular light colors, such as light blue, light red and pearl white. As the Yuan dynasty was a dynasty established by the Mongolians, it was a dynasty that revered nature and had more brown colors, and the popular colors of costumes included gold, taupe, white and so on. Ming dynasty costumes pay attention to color matching, and their style is gorgeous. The popular colors include bright red, emerald blue, grass green, grape violet. The costumes color system of Qing dynasty is more complex, it was mixed with Han and Manchu style, clothing popular colors include: blue, cyan, apricot yellow, etc., and Manchu especially love blue.

China's clothing patterns are rich and colorful, and their scope is extremely wide. There are plant patterns, animal patterns, geometric patterns, character story patterns, auspicious patterns and so on. At the same time, China's patterns have also gone through a stage from abstract to realistic, see Fig. 5. The pattern not only represents its unique symbolic meaning, but also a symbol of status. During the Xia, Shang and Zhou dynasties, costume patterns were simpler and more abstract, showing the beauty of patterns with pictorial patterns. After the Zhou dynasty, the costume patterns gradually became neat, from abstract to realistic, and there was also a combination of abstract and realistic. During the Eastern Han dynasty (25 AD-220 AD), the animal cloud pattern and the Chinese character



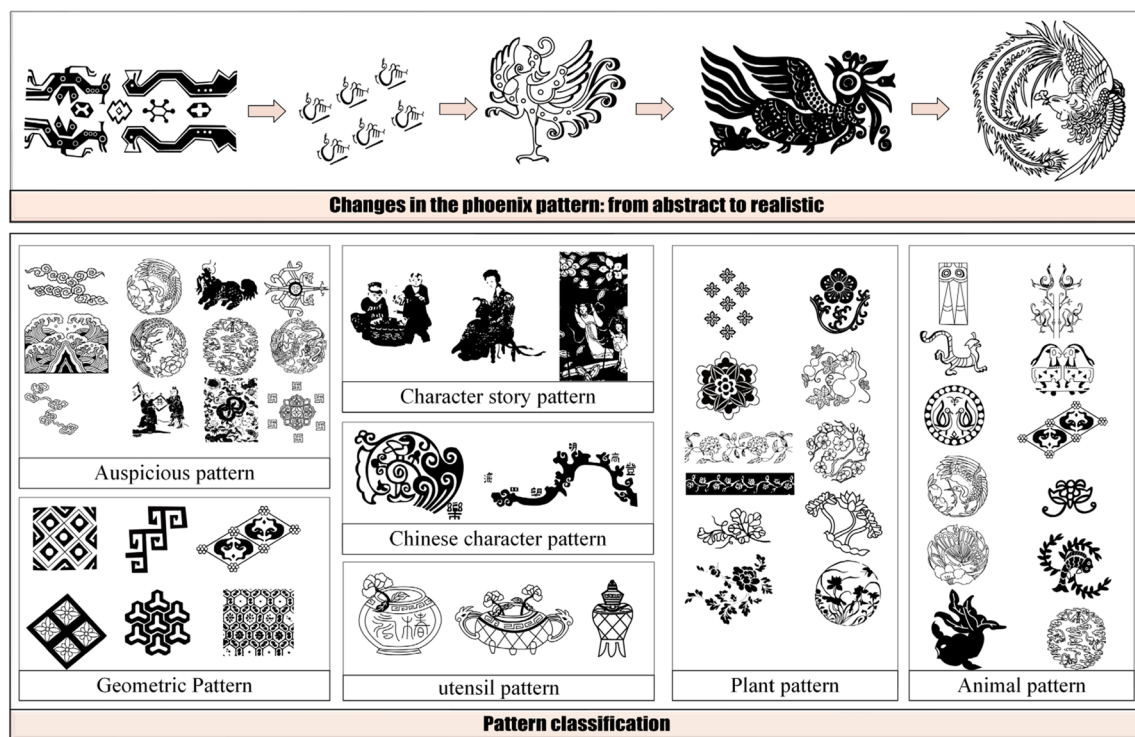


Fig. 5 Chinese traditional patterns

auspicious language pattern were popular for a while. During the Wei, Jin, Northern and Southern Dynasties, due to the integration of foreign cultures, some of the patterns at this time were combined with Buddhism and other cultures. In the Tang dynasty, due to the prosperity of culture and economy, the dress patterns were exquisite and splendid, including the linked-bead pattern, the lotus flower pattern, the composite flowers pattern and the interlock branch lotus pattern. In the Song dynasty, while inheriting the style of the Tang dynasty, the patterns of the Song dynasty were also added with the patterns of utensil. Moreover, the patterns of the Song dynasty were more rigorous and realistic. In the Ming dynasty, the patterns also added auspicious patterns with obvious symbolic meanings to express the good wishes of people's hearts. In the Qing dynasty, the distribution of costume patterns also pays attention to symmetry and perfection, and the patterns are vivid and realistic.

Analysis of recovery objects

In this paper, we analyze the costume style, pattern and costume construction from the perspective of garment engineering and archaeological knowledge for each dynasty costume artifacts. We use fashion software to

draw style diagrams, and use 3D interactive garment pattern-making technology to develop construction diagrams [37]. The analysis of the costumes of the Chinese dynasties is shown in Table 1.

3D digital recovery process

In this paper, we analyze the costume relics, use Adobe illustrator software to draw the costume style diagrams, and use Fuyi Garment CAD to draw the costume construction diagrams, and use CLO 3D software to realize the 3D digital recovery of the costume finally.

Another major element of costume restoration is the size of the costume. Currently, the height dimensions of ancient people can only be analyzed through heirloom relics, ancient book records, and measurements of ancient human remains. The costume dimensions can be determined through proportional methods and real costume measurements. A scholarly study proved that the average height of human bone specimens in the Qin and Han tombs now excavated nationwide is about 167 cm for males and 152 cm for females [38]. However, the height of people varied from dynasty to dynasty and region to region due to different geographical environments and living conditions. Therefore, in order to better display the traditional costumes of the past dynasties, the costumes for which accurate data are not available are

Table 1 Restoration and analysis of style, pattern and structure of Chinese costumes in past dynasties

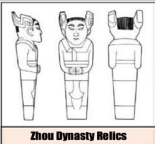


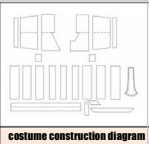
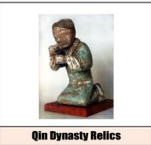


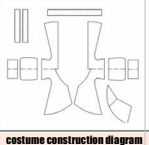

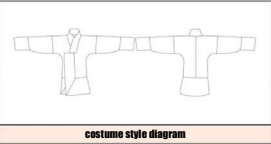
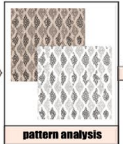
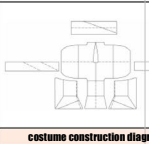
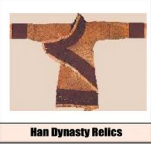

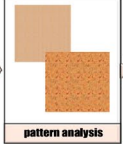
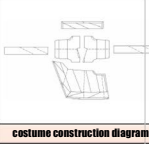
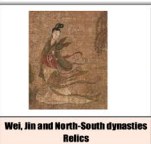

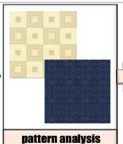
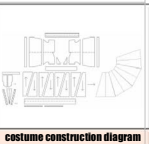
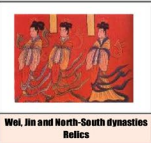


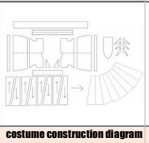
Costume analysis of the dynasties			
Zhou dynasty costume (1046B.C.–256B.C.)			
The jade figures of the Western Zhou unearthed in the eastern suburbs of Luoyang, China: square collar, narrow sleeves, right-overlapping collar, Bixi (蔽膝). Bixi is a large scarf around the front of the dress			
			
Zhou Dynasty Relics	costume style diagram	pattern analysis	costume construction diagram
Qin dynasty costume (221B.C.–206B.C.)			
Painted terracotta figurines unearthed in Xianyang, Shaanxi, China: Quju robe, narrow sleeves, Sanchong costume (三重衣), showing the inner collar.			
			
Qin Dynasty Relics	costume style diagram	pattern analysis	costume construction diagram
Han dynasty costume (202B.C.–220A.D.)			
Mawangdui (马王堆) printed colorful yarn silk robe: cross-collared, right lapel, narrow sleeves, Zhiju			
			
Han Dynasty Relics	costume style diagram	pattern analysis	costume construction diagram
Mawangdui Luodi period embroidered silk floss robe: cross-collared, right lapel, narrow sleeves, Quju			
			
Han Dynasty Relics	costume style diagram	pattern analysis	costume construction diagram
Wei, Jin and North and South Dynasties costumes (220A.D.–589A.D.)			
Gu Kaizhi's painting of "Luo Shen Fu (《洛神赋》)": cross-collared, right lapel, wide sleeves, and streamers protrude from the apron			
			
Wei, Jin and North-South dynasties Relics	costume style diagram	pattern analysis	costume construction diagram
Lacquer Screen of Northern Wei Dynasty Unearthed from Sima Jinlong Tomb in Datong, Shanxi, China: cross-collared, right lapel, the pointed dovetail is lengthened and integrated with the apron			
			
Wei, Jin and North-South dynasties Relics	costume style diagram	pattern analysis	costume construction diagram
Sui dynasty costume (581A.D.–618A.D.)			
North side of the east wall of cave 303 of Mogao Grottoes in Dunhuang, China: short Ru, small sleeves, a long skirt, and the skirt is tied with a ribbon			

Table 1 (continued)








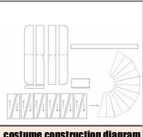



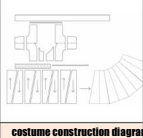





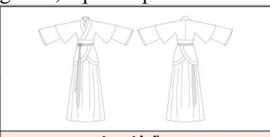

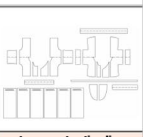


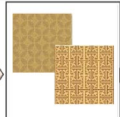
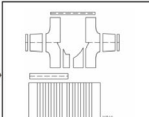



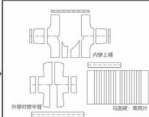

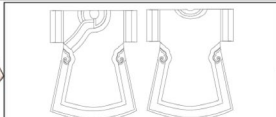


 Sui Dynasty Relics	 costume style diagram	 pattern analysis	 costume construction diagram
Tang dynasty costume (618A.D.–907A.D.)			
“ <i>Beauties Wearing Flowers painting</i> (《簪花仕女图》)”: large sleeves, front opening raiment, wearing long skirts and shawls; Use leno as clothing material			
 Tang Dynasty Relics	 costume style diagram	 pattern analysis	 costume construction diagram
“ <i>DaoLian painting</i> (捣练图)”: small-sleeved, chest-length skirt, wear a shawl			
 Tang Dynasty Relics	 costume style diagram	 pattern analysis	 costume construction diagram
Song dynasty costume (960A.D.–1279A.D.)			
Purple-grey crepe trimmed narrow-sleeved Beizi unearthed from Huangsheng’s tomb in Fuzhou, China : long sleeves, long body, front opening, and both sides are slit to the armpit			
 Song Dynasty Relics	 costume style diagram	 pattern analysis	 costume construction diagram
Yuan dynasty costume (1271A.D.–1368A.D.)			
The Yuan dynasty mural “ <i>The Royal Palace Shang Bao Tu</i> (《王宫尚宝图》)” in the Water Temple of Guangsheng Temple, Hongdong County, Shanxi, China: cross collar, half arm, long robe, top coat-plus-skirt form			
 Yuan Dynasty Relics	 costume style diagram	 pattern analysis	 costume construction diagram
Ming dynasty costume (1368A.D.–1644A.D.)			
Ming dynasty dark green gauze woven gold cloud shoulder phoenix short shirt:			

Table 1 (continued)

cross-collar, right lapel. Wear a horse-faced skirt				
				
Ming Dynasty Relics	costume style diagram	pattern analysis	costume construction diagram	
Portraits of couples in Ming dynasty: wearing Ru on the inside, wearing half arm on the outside, and wearing horse-face skirt on the bottom				
				
Ming Dynasty Relics	costume style diagram	pattern analysis	costume construction diagram	
Qing dynasty costume (1636A.D.–1912A.D.)				
Purple gauze ground scattered pattern Changyi in late Qing dynasty: round collar, wide sleeves, slit on both sides, inlaid with rolling colorful embroidery				
				
Qing Dynasty Relics	costume style diagram	pattern analysis	costume construction diagram	

now restored according to the Chinese national standard GB/T 1335.2–2008 women's clothing size. 165/88A can be used as a unified size for restoring clothing. The proportional method is used to judge the costume size. The structure of the costumes with known costume size data is drawn according to the data measured from the originals.

After drawing the structure diagrams of the Chinese costumes using Fuyi Garment CAD, we import structure diagrams into the virtual simulation software in DXF format. First, we select the human model in the virtual simulation software and set the model parameters. After that, we import the structure diagrams in DXF format, place them on the 3D virtual body through the arrangement points on the model, and sew the 3D virtual body in the order of the costumes from inside to outside. After finishing sewing, the garment needs to be adjusted in the virtual try-on state to achieve the best display effect. At the same time, according to the analysis of the clothing fabric, pattern and color, we set the fabric properties, color and pattern of the restored costumes. Finally, the restored traditional costumes are completed, see Fig. 6.

Result

The historical change of ancient Chinese costumes is to analyze the style, structure, fabrics, patterns and colors of ancient costumes from the perspective of

garment engineering and archaeology. Secondly, the style diagrams are drawn. Then, the structure diagrams are developed. Finally, the virtual simulation software is used to restore the costumes. The results of the 3D digital restoration are shown in Fig. 7.

Chinese ancient costume is the symbol of Chinese ancient culture. The changing history of ancient Chinese costumes is also a record of the development of China's textile industry, culture and belief. As the shape of Chinese costumes was influenced by Confucianism, the garments were wide and rarely showed the beauty of human curves. The structure of the costumes was mostly flat and cross. The colors of traditional Chinese costumes come from nature, heaven and earth. The colors of costumes also have the role of intention and status symbols. The "five colors" were used as the right tone in ancient times. China's silk culture has existed for thousands of years. Silk as the characteristics of Chinese fabrics occupies an extremely important position. The fabrics of Chinese ancient costumes include hemp, kudzu, leather, wool and cottons.

Discussion

This paper studies costume restoration using artifacts related to traditional costumes, including: costume objects, murals, figurines and ancient paintings. Costume restoration needs to comply with the characteristics of the period. The correct costume elements should be



selected for the period in which the costume is located. The costumes recovered in this paper follow the three evidences of costume recovery: images, objects and documents [39]. The 3D digital costume models can clearly show the structure, style, pattern, etc. The comparison with the pictures of cultural relics shows that the overall effect of our restored costumes is good. For some cultural relics that do not clearly show the full image of the costume, the restored costumes conform to the characteristics of its time based on literature. The use of digital restoration to display traditional costumes also saves human and material resources. We provide a new way for the restoration of traditional costumes.

China has a long history and culture. Costumes have been changing with the changes in history. The history of what once was, and the way of life of the ancients, has also become gradually blurred as time goes by. The costumes of the past have gradually become tattered with the erosion of time. However, the efforts of archaeologists have allowed these once hidden costume relics to

begin to reappear, providing an incomparable wealth of information for the study of Chinese material culture and allowing us to witness the history that was once there as well. With the passage of time, some of the ancient costumes have decomposed, disappeared or only some fragments remain. We use representative cultural relics to make digital restoration from the perspective of garment engineering and archaeology. The history of the past can leap onto the paper, and present the development of ancient Chinese costumes. The culture, customs, social style and living conditions of each dynasty more directly convey historical and cultural information.

The history of ancient Chinese costumes, a history worn on the body, is the bearer of ancient Chinese society, which contains the rich thoughts and spirit of the ancients and reflects the socio-economic, cultural and aesthetic consciousness of each dynasty. The change of Chinese clothing culture is the inevitable result of historical development, and the aesthetic consciousness of each period is closely related to the dynasty in which it is



Fig. 7 Costume restoration display

worn. The change of dynasties, the constant new things, and the impact of foreign cultures have all influenced and greatly enriched the Chinese costume culture. Although the costumes of each dynasty have their own unique features, they complement each other and have certain

connections. The costumes of each dynasty together constitute the deep connotation of Chinese costume culture.

Traditional Chinese ancient costumes are an important part of China's historical civilization. They have been used throughout the 5000 years of Chinese history.

However, most of the information people receive about ancient costumes in their daily lives nowadays comes from movies and TV dramas, Chinese cultural activities, and improved Chinese costumes, which have deviations from traditional ancient costumes in different degrees. In order not to let our traditional Chinese costumes become theatrical costumes with historical deviations to mislead people. Scholars of ancient costume research should correctly guide the public to understand the shape and wearing method of our traditional costumes, let the public understand the characteristics of costumes of each dynasty, let the history of a thousand years ago, correctly placed in front of the world, let the cultural style of the past spread again, and let our traditional costume culture continue to be inherited. And this paper uses virtual reality technology to display traditional costumes of all generations, which is also more convenient for the world to observe the correctly restored traditional Chinese costumes.

Traditional costume is not only a piece of costume that marks the history of China, but also shows the culture of China for thousands of years. The historical changes of Chinese costumes are presented in representative costumes of each dynasty, which will be helpful for scholars who study ancient Chinese costumes at a later stage. The restored costume models provide research materials for the traditional restoration methods. The digitally restored costume display breaks through the limitations of time and space, allowing traditional costumes to be viewed anytime and anywhere, and is valuable to the education industry of ancient Chinese costumes. Displaying restored costumes in digital form breaks through the limitation of time and space, so that traditional costumes can be viewed anytime and anywhere, which is of great significance to the spread of costume culture.

In this paper, static simulation of ancient costumes is only restored. Dynamic simulation can express the cultural connotation of ancient costumes more intuitively. Therefore, the dynamic virtual simulation of ancient costumes will be an important research direction in the future.

Conclusion

In this paper, we use 3D digital technology to select some representative costumes from ancient Chinese costume archaeological relics. By analyzing the style, pattern, fabric, structure, etc. of the costume, we virtually reconstruct the costumes of Chinese dynasties.

- 1) The historical changes of Chinese ancient costumes were constantly changing according to the changing environment of the times, culture, customs and ethnic beliefs. With the continuous development of

history, people's production technology continues to improve, and the constant changes of social economy drive the change of clothing structure, color, pattern and fabric.

- 2) The most basic form of Chinese ancient costumes was the top coat-plus-skirt and costume with connected tops and bottoms. Later on, influenced by the culture and customs of ethnic minorities, the form of upper garment and lower pants also gradually appeared. These costume forms constitute the valuable Chinese costume culture.
- 3) The traditional Chinese concept of the five elements gave rise to the five colors system, which became the "pure color (纯色)" in the Chinese color system. The color of the costumes in different dynasties also changed with the beliefs and aesthetic concepts of the dynasty.
- 4) Chinese costume patterns are the epitome of ancient Chinese culture and thought. The allegorical meanings manifested by the patterns reflect the spiritual and cultural connotations of different eras.
- 5) This paper makes a virtual simulation of the historical changes of Chinese ancient costumes, which shows the development of ancient Chinese costumes in a more complete way. It enriches the study of ancient Chinese costumes and also provides another way to preserve and inherit the Chinese costumes in the past generations by using digitalization.

Future research can be further carried out from the following four aspects:

- 1) Dynamic virtual simulation of ancient Chinese costumes will be an important research direction in the future;
- 2) Building a digital museum based on the restored 3D digital costumes to show the historical changes of Chinese traditional costumes more vividly.
- 3) Designing modern fashion based on the characteristics of each dynasty's costume to promote traditional Chinese culture in another way.

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Author contributions

KL developed the research idea. Shunmuzi Zhou and Chun Zhu wrote the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials

The datasets generated during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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