Principles of Pattern Modification of Court Costume in Ming Dynasty in 3D Simulation

Junqiang Su, Anlu Liu, Jinzhu Shen, Nan Wang, WeiFeng Dong

ABSTRACT

Due to the particularity of ancient Chinese costume patterns, algorithm errors often occur in 3D simulation of ancient Chinese costume, resulting in failure of costume simulation. When reconstructing those costumes with research value, the influence of the garment structure on the effect of the garment model should be taken into account, and the garments should be reconstructed with real patterns. However, in order to reduce the algorithm errors in the costume simulation process, the authenticity of the pattern must compromise the limitations of the software algorithm, that is, the original pattern of costume must be modified. This paper, taking the court costume of Ming Dynasty as the research object, summarizes the parts where algorithm errors occur in the virtual simulation process of court costume. Through specific experiments, the effect of costume models made by different patterns is compared, the modification method of Ming Dynasty costume pattern in CLO3D is explored. The pattern modification principle that can eliminate algorithm errors in simulation process to the greatest extent is determined, and a set of court costume pattern used for 3D simulation is established. This pattern modification principle is applicable not only to the Ming Dynasty court costume, but also to all the ancient costumes with the same structure as them, which provides the theoretical basis and experimental method for the establishment of other ancient costume models.

KEYWORDS

Historical costume simulation, Costume virtual reconstruction, Modification of pattern, Cultural protection.

INTRODUCTION

The main component of textile cultural relics is organic matter. They are continuously degraded by environmental factors such as light, dust, temperature, humidity and physical pressure. Therefore, compared with other cultural relics, textile cultural relics are more difficult to be restored. The ancient clothing cultural relics are characterized by fragility.

On the one hand, the exhibition of textile cultural relics have very high requirements on the temperature, humidity and other conditions of the external environment. During the clothing exhibition, changes in lighting, temperature and
humidity will affect the texture or color of the clothing. If pollutants or dust are adsorbed into fabrics due to static electricity and other factors, it is difficult to remove them. If the clothing cultural relics are dry cleaned or washed again, irreparable damage will be caused to them and the previous repair effect will be seriously affected. On the other hand, the costume heritage is very precious. There is a distance between the costume heritage and the visitor. For visitors, it is difficult to appreciate every detail of the costume in 360 degrees, let alone the dynamic ancient costume.

For the above reasons, ancient costumes and cultural relics cannot be exhibited for a long time. Visitors can only visit and learn the static exhibition of clothing cultural relics within a limited period of time. And they have no interaction with clothing cultural relics. Visitors have low acceptance of clothing cultural information.

Therefore, many scholars at home and abroad propose to combine 3D virtual simulation technology with ancient clothing. The three-dimensional virtual simulation technology is used to accurately reconstruct the ancient clothing cultural relics from the aspects of clothing size, clothing style and structure, clothing material, clothing color, clothing production technology. The garment heritage can be digitized. The reconstructed clothing model can be directly exhibited online, which not only avoids the damage to clothing in the exhibition process, but also greatly reduces the cost of clothing exhibition. The 3D simulation model of ancient costume can be applied to various applications for exhibition and education in the new media environment, which increases the dissemination of ancient Chinese costume culture[1].

At present, the reconstruction of costumes uses different methods: 3D apparel CAD, 3D modelling application and 3D scanning technique. 3D apparel CAD for costume reconstruction presented more delicate structures as they were based on garment patterns. Costumes reconstructed by 3D modelling application do not express accurate structural features and details. Compared with the above two technologies, the clothing model made by 3D scanning technology is more authentic. However, clothing model made by 3D scanning technology do not have the capacity of simulation of dynamic drape because the structure of the garment is not considered[2]. Therefore, the accuracy of the virtual clothing model obtained based on the real pattern is higher. However, due to the particularity of ancient Chinese costume patterns, algorithm errors often occur in 3D simulation of ancient Chinese costume. In the digital reconstruction of garments with historical research value, not only the influence of clothing structure on the effect of clothing model, but also the conflict between ancient clothing structure and software algorithm should be considered, that is, the original pattern must be modified under the condition that they are as close to the reality as possible to eliminate the algorithm errors in the costume simulation process.

In this experiment, we chose the court costume from Duke’s Yansheng’s government in the Ming Dynasty for virtual reconstruction. In the process of reconstruction, this paper summarizes the problems encountered in the simulation of the costume by using the real pattern of the court costume and puts forward a modification scheme for the patterns of the court costume in view of those problems. Through these, this study determines the feasibility of modifying the patterns to adapt to the software algorithm and improve the efficiency of costume simulation.
STRUCTURAL ANALYSIS OF HISTORICAL COSTUME

In this study, the three-dimensional model of ancient costumes is produced based on Garment CAD technology, which means that we generate virtual reconstruction of ancient costumes based on clothing patterns. Therefore, before the reconstruction of historical clothing, we should make a detailed structural analysis of historical costumes and draw the pattern of historical costumes.

The court costume reconstructed are those of Duke Yansheng of Confucius House collected by Shandong Museum. It was carefully kept by the Duke Yansheng family of past dynasties. The objects are basically intact and have been sealed up for more than 300 years. It is the only set of Ming Dynasty court costume handed down from ancient times with the most complete preservation so far. Clothing handed down from ancient times is usually brightly colored and well preserved. It shows the outstanding design ability and advanced aesthetic attainments of Ming Dynasty craftsmen. The clothing has rich historical information and high research value. 3D simulation of court costume is of great significance to the propagation of costume culture.

Among the costumes of Ming Dynasty, the court costume was typical, with many patterns and complicated structure. Therefore, the pattern modification principle of court costume can also be applied to other costumes with the same structure as it, which has certain guiding significance for the virtual reconstruction of other costumes.

Therefore, in this experiment, this paper takes the court costume as the research object, collects the data of the court costume and analyzes the structure of the court dress. The pattern of the court dress is restored to the greatest extent, and the influence of structural factors on the simulation effect of the three-dimensional model is reduced to the lowest.

In order to reconstruct the court dress accurately, the data collected in this paper are provided by Shandong Museum. The size data of the court dress are shown in the figure below:

![Figure 1. The size of the court dress.](image)

In order to get an accurate pattern of the costume, we made a precise structural analysis of it. It can be seen that the structural design method of the court costume is a typical Chinese cutting method. The upper dress consists of four pieces of fabric, each piece of fabric has a width of about 65cm. Collar, cuffs, lapel and hem are all pasted with edges made of blue silk with a width of about 15cm. Considering the comfort and
beauty of wearing, the armpit of the front of the court dress piece respectively receives two pleats with upper width and lower width and the widest part of about 5-10cm. The back piece of the court dress piece does not accept pleats. The left front of the court dress is spliced in the central front, tied to the right armpit with a tie band, which not only increases the amount of movement, but also makes the court dress more elegant when wearing. The lower dress is divided into two pieces, partially overlapping, with two sides receiving flexible pleats. Each piece is sewn together with two pieces of fabric, and eight pleats are respectively made. And the overlapping parts in the middle of the two pieces do not receive pleats[3]. We made a precise structural analysis of the court costume and restored the pattern of the costume according to the historical information. The pattern is as follows:

![Figure 2. The structure diagram of the court dress.](image)

**MODIFICATION OF THE PATTERN OF COURT COSTUME**

In the process of reconstructing ancient costumes by using CLO3D, a software for virtual fitting of modern costumes, it can be found that due to the special pattern and special manufacturing process of ancient costumes, there are some problems in reconstructing ancient costumes by CLO3D. And, there is a great difference between ancient costumes and modern costumes in terms of production technology. All these have led to the failure of costume simulation.

In order to eliminate the algorithm errors in the simulation process, the ancient clothing pattern must be modified on the basis of the real pattern to adapt the pattern to the algorithm in the CLO3D simulation process. The best modification scheme is determined by comparing the model effects of different pattern of court costume. This method has reference significance for the digital reconstruction of other ancient costumes with the same structure and manufacturing technology as the court costumes of the Ming Dynasty.

As the structural design of the costume adopts a typical Chinese cutting method, the center front and the center back are the central symmetry axis of the garment, the
shoulder line is the horizontal axis of the garment. When arranging the costume pattern, the left, the right, and the sleeve of the garment can only be arranged in the same horizontal plane. And they cannot be placed around the virtual model. The arrangement of pattern plays a decisive role in the success of clothing simulation. Therefore, the arrangement of pattern should use the function of arrangement points to fit the virtual models as much as possible, so as to ensure that the software algorithm does not make mistakes in the process of costume simulation. In order to enable the garment component to be placed around the virtual model, the body pieces and sleeve pieces need to be divided along the shoulder line. After the pattern is segmented, the garment pieces can be placed around the virtual model before simulation, thus avoiding algorithm errors caused by the pattern not fitting the virtual model. Then, the costume is sewn and simulated according to the manufacturing process of the costume. Some algorithm errors occurred in the neckline, armpit, shoulder, hem and other positions of the simulated costume, as shown in the following figure.

However, the structure of neckline, armpit, shoulder, edge and other positions of the court costume is complex, so it is impossible to directly determine the pattern modification scheme. It is necessary to determine the final pattern modification scheme by comparing the simulation effects of different patterns modification scheme.

![Figure 3. The effect of the clothing model based on the original pattern.](image)

Therefore, this paper designs different pattern modification schemes for different parts of clothing with algorithm errors. The parameters of particle distance setting and fabric properties are the same in the experiment. The particle distance is set as 20, the warp and weft yarn strength in fabric parameters is set as 49, diagonal tension is set as 45, bending strength of warp and weft yarn is set as 50, deformation rate of warp and weft yarn is set as 10, deformation strength of warp and weft yarn is set as 80, and density is set as 15. The experiment only changed the pattern of the court dress. We observed and recorded the degree of error elimination of the software algorithm in the simulation process of the court costume model, and evaluated the model effect.

**Modification Scheme of Waist Pleats**

Waist pleats were used very frequently as a decorative method in Ming Dynasty costumes. The pleats of the reconstructed costume are distributed on both sides of the waist. The following figure is a perspective view of waist pleats. Based on the analysis of the structure of the court costume, two modification schemes of waist pleats are proposed, both of which are based on the original model of the court costume.
1) Method 1: Cut the waist pleat along line a, line b, line c and lined, and divide the complete waist pleats into pattern A, pattern B, pattern C and pattern D.

2) Method 2: From the perspective of waist pleats, it can be seen that the pleat pattern is hidden behind the garment piece, which is not visible in the appearance of the costume. The pattern of pleats can be deleted, and only the pattern B and pattern D can be retained.

The model effects of the two methods are shown in the figure below.

By comparing the two methods, it can be seen that the two modification schemes are both suitable for the software algorithm compared with the original pattern. And from the perspective of clothing appearance, there is almost no difference in model effect between the two schemes. From the overall appearance of the garment, although the pattern in method two avoided the algorithm error in the simulation of waist pleat, the lack of pattern affected the appearance of the front hem of the costume. In addition, based on the principle that patterns must be as close to the real one as possible, method one should also be chosen.

![Figure 4. Perspective view of waist pleats.](image1)

![Figure 5. The model effects of the two methods.](image2)

Modification Scheme of Front Hem

Due to the complicated structure of waist pleat, the software generated algorithm error when sewing the blue silk at the hem of the front piece, which resulted in the failure of garment simulation. The hem pattern needs to be modified on the basis of the original pattern. The modification scheme of pattern is shown in the figure below:
1) Method 1: Divide the original block into two pieces and separate the edge pattern of the piece of costume sewn in the front from the remaining part of the edge pattern.

2) Method 2: Divide the original rectangular pattern into six pieces according to the pleats at the hem.

3) Method 3: Change the shape of the original pattern and draw the hem edge pattern according to the shape of the hem.

By comparing the effects of the three models, as shown in the figure below, it can be seen that the pattern corresponding to method three is the same as the original pattern, which will lead to algorithm errors in the simulation process of virtual clothing. Although the pattern of method two and method one can avoid the algorithm errors in the simulation process of court dress, the paper pattern modified according to method two has a better simulation effect from the perspective of authenticity.

Modification Scheme of Collar

Based on the detailed analysis of collar structure, three pattern modification methods are proposed:

1) Method 1: Cut the collar pattern at the shoulder line, divide the pattern into three pieces.

2) Method 2: Cut the collar pattern at the shoulder line, divide the pattern into three pieces, and delete all the overlapping collar pattern on this basis.

Method 3: Cut the collar pattern at the shoulder line, divide the pattern into three pieces, and delete part of the overlapping collar pattern on this basis.
The model effects of the three methods are compared, as shown in the figure below. The pattern corresponding to method one is the same as the original paper sample, which will lead to algorithm errors in the simulation process of virtual clothing. The pattern corresponding to method two and three eliminates the algorithm error in the process of clothing simulation. The method two completely deleted the hidden part in the collar and sewed the collar into a completely closed ring, which is not consistent with the real situation. Method three not only eliminates the algorithm error in the simulation process, but also ensures the appearance of the model.

**VIRTUAL RECONSTRUCTION OF COURT COSTUME**

Through the above experiments, the pattern modification principle that can eliminate the algorithm error in the simulation process of court dress to the greatest extent is determined, and a set of court dress pattern for 3D simulation is established.

**Virtual Sewing**

Virtual sewing of CLO3D is basically the same as actual sewing. In order to achieve realistic effect, actual sewing method should be adopted as much as possible in the sewing process. The arrangement of the pattern plays a decisive role in the
success of the costume simulation. The modified pattern can be placed around the virtual model. Simulation was carried out after the sewing of the garment.

Fabric Simulation

The realistic effect can be simulated in CLO 3D because of its powerful fabric regulation system, including basic and physical properties of fabric. In terms of physical properties of fabric, it is impossible to measure the fabric properties of clothes, but the realistic effect can be achieved by adjusting their physical properties.

Finally, the costume modeled by CLO 3D software is shown in the figure. By comparing the virtual clothing model with the real costume, the overall silhouette, color, fabric texture, drape and wearing effect of the costume are basically the same.

![Figure 10. Three model effects of the three methods](image)

DISCUSSION

Taking Ming Dynasty costume as an example, this paper studies the principles of pattern modification of costume pattern in 3D simulation based on CLO3D and draws the following conclusions:

The area of ancient Chinese clothing pattern is large, and it is easy to generate simulation errors in the 3D simulation process due to the limitation of software algorithm. The segmentation or deletion of the garment pattern to reduce the area of the garment pattern can effectively avoid algorithm errors in the simulation process.

In order to reduce the software algorithm errors in the 3D simulation process, the principle of pattern modification should be used in the 3D simulation of the ancient clothes with the collars overlapping on the left and right sides: retain part of the pattern in the overlapping area of the neckline, and delete all other overlapping pattern. This conclusion is of reference significance for the digital reconstruction of all the overlapping collars of ancient costume, and provides theoretical basis and experimental methods for the establishment of models of other types of clothing.

The structure of pleat is widely used in ancient costume, but 3D simulation of costume with pleats will generate simulation error. For ancient clothing with pleat structure, its pattern modification principle in the process of 3D simulation is as follows: cut the pattern along the pleat. This conclusion can be used for reference for the digital reconstruction of ancient clothing with pleat structure.
ACKNOWLEDGEMENTS

Corresponding author: Junqiang Su

REFERENCES

1. K. Yeonkyung, W. Sehee, M. Kathi, “Digital Production of Traditional Costumes,” Digital Heritage International Congress. London, pp. 329–335, May 2013.
2. K. Zi Young, C. Tracy, and C. Tom, “Historic Costume Simulation and its Application,” 15th Autex World Textile Conference. Romania, pp. 1-24, 2015.
3. M. Fenfen, J. Yan, “Study on Tibetan Robe Pattern with Cross Collars Based on CLO 3D,” Beijing, vol. 38, pp. 11–18, 2018.