The establishment of the digital model of Mongolian robe and virtual display

Hui Shi¹, Xiao Yu¹, Yunjuan Liu², Shuai Yu¹, Suqi Tian¹, and Wu Yang¹

¹College of Light Industry and Textiles, Inner Mongolia University of Technology, Hohhot, 010080, China
²Fujian Clothing Industry Technology Development Base, Fuzhou, Fujian, 350108, China
Hui Shi: shihui180206@imut.edu.cn

Abstract. The aim of this study was to establish the 3D virtual model of the Mongolian Zarut tribe male Mongolian robe (MZTMMR). This study designed 2D planar patterns of MZTMMR in Gerber CAD software. A 3D fabric texture of MZTMMR was established using planar image processing technology. A virtual male model of 175/88A After imported into CLO 3D, the 2D planar patterns was arranged around the male model and then sewn into virtual MZTMMR as created in CLO 3D software. The 3D fabric texture was pasted on the virtual MZTMMR. A virtual 3D model of MZTMMR was established in this study. Meanwhile, the method of building a virtual 3D model of MZTMMR included 2D patternmaking, 3D fabric texture creation, human model creation and virtual fitting (2D pattern arrangement and virtual sewing). The findings of this study are useful for providing technical support for cultural research, protection, display and inheritance of traditional Mongolian clothing culture.

1. The status of digital inheritance of traditional Mongolian costumes
Mongolian costumes is a typical representative of the intangible cultural heritage of ethnic minorities, and it is a perfect fusion of decoration, practicality and symbolism. In recent years, with the gradual disappearance of the nomadic lifestyle of the grasslands, the use of Mongolian costumes of various tribes has changed. Not only styles and types have gradually decreased, but also even some exquisite traditional Mongolian costumes have gradually disappeared or been destroyed. The same is true for traditional handicraft techniques. It has gradually declined or even disappeared. So it is imperative to inherit and protect the Mongolian costume culture[1]. At present, the inheritance method of Mongolian traditional costumes is relatively simple, mostly based on static measurement, restoration, imitation, which must be taken as the carrier, which is not conducive to the long-term and vivid display of the overall characteristics of Mongolian costumes, nor can it be comprehensive and dynamic. Dressing effect[2], the virtual clothing technology is inspired by the traditional costumes model design and sample production process, through the establishment of a 3D virtual human model[3][4], face accessories virtual model[5]; 2D structure parametric design[6], use 3D virtual design software for virtual stitching[7], establish a 3D human dressing model, and achieve virtual display, which can make the precious national cultural treasure Mongolian costumes presented to the world in digital 3D form.

Clothing modeling technology and virtual display technology have been fully utilized in the display of precious cultural relics. Ma [8] proposed a method of deleting the Tibetan robe model structure and used the CLO 3D system restoration method of the Tibetan robe fabric map. She established a Tibetan
costume display system, which provides a technical basis for the establishment of digital models of cultural relics. With the in-depth study of virtual clothing modeling technology and the improvement of the demand for virtual experience, the virtual display model of clothing has gradually changed to 3D, realistic, and interactive experience. Scholars such as Shgeru Inui[9] used Leap Motion as a sensor to detect the movement of hands and fingers, dynamically modeled the fabric, and numerically calculated the dynamic shape to realize the virtual 3D cutting of clothing. Michael B. Holte[10] proposed a method of making digital clothing based on a virtual fitting room, using RGB-D sensors to scan real clothes first, and then creating digital clothing by professional programs (such as Marvelous Designer2). Scholars such as Hsien-Tsung Chang[11] used Kinect and AR technology to construct a dynamic virtual fitting room that can automatically measure the size of clothes. Scholars such as Xinjuan Zhu[12] proposed an interactive clothing design scheme and a personalized virtual display scheme with the user's own face, and developed a set of 3D web-based personalized clothing customization based on Unity 3D and VR technology Prototype System. Diverse apparel virtual display technology combination applications create a realistic, omnidirectional and interactive digital apparel model. This study takes the Mongolian Zarut tribe male jacket as an example, combined with the clothing structure technology, planar image processing technology, 3D human model and virtual display technology, to study the establishment and display of Mongolian robe virtual model.

2. Virtual modeling methods and processes
The modeling process of the MZTMMR is divided into three stages, which are specimen data collection and 3D human body modeling; model and fabric restoration; and virtual model production, as shown in Figure 1.

2.1. 3D human body modeling
Select a 175/88A young man to measure his body size using contact anthropometry. Create a virtual human model in CLO 3D software that matches the real body shape.

2.2. Model and fabric restoration
Make typical styles of Zarut robe. Use Gerber CAD to draw a DXF format 2D structure drawing that has been verified by the sample garment. Collect fabric images, and use plane image processing technology to restore their realistic digital images, and then use CLO 3D software to build fabric virtual texture.

2.3. Making virtual models
After the model and the digital model of the fabric are completed, use the CLO 3D software to complete the work of model stitching, fabric filling, fabric texture and physical property adjustment, and trim detail simulation, and establish a virtual model of a static Zarut robe. Finally, add rendering effects such as scenes to the CLO 3D display interface to achieve dynamic display of the model.

3. The establishment and display of the virtual model of the Mongolian Zarut tribe male robe

3.1. 3D virtual human model

The mannequin is the main body of the virtual dress, so its shape, size and posture are particularly important in the virtual display of clothing. This chart is based on the collection of static human body data of 26 parts of the 175/88A male model (Table 1).

**Table 1. 175/88A male model size information table(Unit: cm)**

| Height | Cervical height | Waist to hips | Hip height | Knee height | Neck height | Shoulder width | Arm length |
|--------|-----------------|---------------|------------|-------------|-------------|----------------|------------|
| 177    | 150.5           | 25            | 91.5       | 49          | 6.8         | 42.5           | 56.2       |

| Upper arm length | Head girth | Neck girth | Back bust length | Back waist length | Bust girth | Waist | Hips |
|------------------|------------|------------|------------------|-------------------|------------|-------|------|
| 33               | 55         | 42         | 34.5             | 38                | 94         | 78    | 95   |

| Upper-arm girth | Elbow girth | Upper arm girth | Wrist girth | Thigh girth | Knee girth | Calf girth | Ankle girth |
|-----------------|-------------|-----------------|-------------|------------|------------|------------|-------------|
| 28              | 25.3        | 25              | 16          | 56         | 38.5       | 37.5       | 21.5        |

The 3D human body model established with CLO 3D software was shown in Figure 2. The virtual mannequin is the male male body A with yellowish skin. There are four types of short, squat, tall and thin, tall fat in the virtual model editor. The real model does not match the four types. Therefore, according to the measurement data in Table 1, the width and height are adjusted in combination with the slide track. Setting the size of the details to achieve the similar purpose of the virtual model and the real model.
3.2. Zarut tribe male robe 2D structure
Based on the 175/88A men's size, a classic style sample of the MZTMMR was made, as shown in Figure 3. The style characteristics of the MZTMMR are: the collar is a rounded stand collar, and the placket uses a curved large placket; the neckline, collar seat, large placket, drape, cuffs, slits and hem are all edging. The sides of the men's robe are slit to the knees to ensure a large movement of the legs. When modeling, pay attention to expressing the effect of the edge of the robe and the state of the buckle connecting the pieces.

Verification by trying on sample to determine the accurate 2D structure of MZTMMR (Figure 4). There are six pieces in total: front placket, sleeve pieces and collar pieces. Export the structure drawing drawn by Gerber CAD to DXF format file. You must first cut all the cut pieces through the style file tool in layout and data editing. All pieces are imported, and the style file of the MZTMMR is established. When creating a style plan, import the pieces in the order from left to right, so that after importing into the CLO 3D software, the pieces will be automatically arranged from left to right in the order of import. Then through the resource manager and the resource conversion tool in the system settings, the MZTMMR cut files stored as style files are converted into DXF-AAMA format.

![Figure 3. MZTMMR effect drawing and style drawing](image)

![Figure 4. MZTMMR 2D structure](image)

3.3. Virtual sewing
Select File-Import-DXF in the CLO 3D software, and import the converted structure chart of the MZTMMR into the 2D panel of the CLO 3D software. Each piece imported into the software needs to
be adjusted in the 2D panel and 3D panel (Figure 5). When sewing virtual garments, the most suitable sewing sequence was determined through multiple experiments. The first step was to sew the collar, back center, front center, sleeves and body; the second step was to sew the side seams of the sleeve and the side seams of the body.

According to the style of the MZTMMR, the front of the body is connected by a buckle, so the front of the body and the bottom of the body must be fixed in the buckle before the sewing simulation. The button position of the men's robe is fixed by the fake sewing tool. After the sewing thread is connected to the simulation, the fabric stitched on the 3D interface will naturally sag, simulating the drape of the fabric in reality. The position of the fabric sag after the simulation needs to be adjusted by the hand tool. Because the fabric is easily deformed and hangs too much, there will be a "through-mold" situation during the adjustment process, so the lining strip is glued to this part and becomes stiff, as shown in Figure 6.

![Figure 5. Placement of pieces in 2D layout and 3D layout](image)

![Figure 6. Suture of the front flap](image)

3.4. Virtual garment fabric simulation
Add the processed fabric to the object window, adjust the basic properties of the fabric texture, color, gloss, etc., and then adjust the physical properties of the fabric strength, deformation rate, density, thickness, etc., to achieve a realistic 3D effect. When the fabric texture image is imported into the CLO 3D software, each plate is imported separately to facilitate the alignment of the fabric texture.
The actual fabric texture is uneven and shiny, and the unevenness of the fabric can be achieved by adjusting the intensity of the normal map of the fabric. When the value is adjusted to 200, the fabric texture has a convex effect, and when the value is adjusted to -200, the fabric texture has a concave effect. According to the unevenness of the fabric, adjust the value to a reasonable value to achieve the desired effect (Figure 7). By adjusting the intensity of the highlight map and the reflection intensity, a gloss similar to the actual fabric is achieved (Figure 8).

![Figure 7. Virtual fabric simulation](image)

The physical properties such as fabric strength, deformation rate, density, thickness, etc. can simulate the appearance of the actual fabric, making the fabric more realistic. The physical properties of this MZTMMR fabric are shown in Table 2.

| Table 2. The physical property values of MZTMMR fabric |
|-------------------------------------------------------|
| (a)  | Strength-weft | Strength-warp | Diagonal tension | Bending strength-weft | Flexural strength-warp | Deformation rate-weft |
|------|---------------|---------------|------------------|-----------------------|------------------------|------------------------|
| Before adjustment | 27            | 27            | 9                | 38                    | 38                     | 80                     |
| After adjustment  | 35            | 35            | 40               | 50                    | 50                     | 40                     |
| (b)  | Deformation rate-warp | Deformation strength-weft | Deformation strength-warp | Internal damping | Density | Coefficient of friction |
|------|------------------------|---------------------|---------------------|-------------------|---------|------------------------|
| Before adjustment | 80 | 80 | 80 | 1 | 27 | 3 |
| After adjustment  | 40 | 50 | 50 | 12 | 37 | 13 |

3.5. Simulation of trim details
The edge of the big lapel of MZTMMR adopts a piping process, and the closing method of the clothing is a plate buckle. In CLO 3D, it is impossible to operate the steps of the actual hemming process, and the method of cutting and stitching the hemming parts is adopted to achieve the visual effect of the hemming process, as shown in Figure 9.
3.6. Virtual model of MZTMMR

The virtual clothing of the MZTMMR rendered using CLO 3D software is shown in Figure 10, and the actual clothing produced by the model is shown in Figure 11. The virtual clothing shows the loose silhouette characteristics of the MZTMMR. The draping effect of the fabric is consistent with the real thing through the setting of the fabric attributes. The 2D structure is controlled by the style. The 3D model is imported to make the Mongolian robe's big flaps, stand collars, The characteristics such as a sleeve and a robe are more realistic. The simulated color is different from the real one, but it can be improved through the operation of color correction.

4. Conclusion

This paper summarizes the style characteristics of the MZTMMR. A 2D structure of traditional MZTMMR was developed using the planar structure method. Besides a 3D male model was created in CLO 3D. The fabric virtual texture was established, using planar image processing technology. The establishment and display of the virtual model of MZTMMR is realized. The appearance of virtual MZTMMR was compared with the appearance of real robe. It was found that the appearance of the virtual robe and the real robe is very similar. The results of this study can provide technical support for the digital inheritance of Mongolian traditional costumes. The application of virtual design on Mongolian costumes provides more possibilities for the inheritance of intangible cultural heritage. It provides more transmission carriers, communication channels and transmission groups for the minority traditional costume culture.

Acknowledgements

This paper is supported by the Open Project Program of Fujian Clothing Industry Technology Development Base, Minjiang University, China(No. MJXY-KF-201902)and the China National Arts Fund Mongolian Traditional Costume(05040220180605621489).
References

[1] Su R and Liu Y 2015 On Symbolic Meaning and Function of Mongolian Costumes in Perspective of Nonverbal Symbols Journal of Minzu University of China. Vol. 4, No. 5, pp 122-128.

[2] Lan Y, Jiang N and Liu M 2013 Discussion between Standardization and Intangible Cultural Heritage’s Protection and Inheritance of Ethnic Minorities Costumes: Taking Mongolian Costumes Standardization Research as an Example China Standardization. pp 110-113.

[3] Krzywinski S and Siegmund J 2017 3D Product Development for Loose-Fitting Garments Based on Parametric Human Models IOP Materials Science and Engineering Conf. 254: 152006

[4] Shi X and He S 2014 Modeling of 3D Personalized Digital Apparel Whole-Human Body Based on Mannequin Components Wen Z, Li T. Berlin, Heidelberg: Springer Berlin Heidelberg Conf. pp 537-547.

[5] Adanur S and Vakalapudi J S 2013 Woven fabric design and analysis in 3D virtual reality. Part 1: computer aided design and modeling of interlaced structures The Journal of The Textile Institute. Vol. 104, No. 7, pp 715–723.

[6] Liu K, Zeng X, Bruniaux P, Tao X, Yao X, Li V and Wang J 2018 3D interactive garment pattern-making technology Computer-Aided Design. 104: pp 113–124.

[7] Berthouzoz F, Garg A, Kaufman D M, Grinspun E and Agrawala M 2013 Parsing sewing patterns into 3D garments ACM Transactions on Graphics. 32(4):85: pp 1-11.

[8] Ma F 2018 The design and implementtation of digital display system of tibetan costume Beijing Institute of Fashion Technology.

[9] Inui S, Mesuda Y and Horiba Y 2015 A Virtual Cloth Manipulation System for Clothing Design. In C. Stephanidis (Ed.) Hci International 2015 - Posters’ Extended Abstracts, Pt I, Vol. 528, pp 185-189.

[10] Holte M B 2017 3D Scanning of Clothing Using a RGB-D Sensor with Application in a Virtual Dressing Room. In V. G. Duffy (Ed.), Advances in Applied Digital Human Modeling and Simulation, Vol. 481, pp 143-153.

[11] Chang H, Li Y, Chen H, Feng S and Chien T 2013 A Dynamic Fitting Room Based on Microsoft Kinect and Augmented Reality Technologies. pp 177-185.

[12] Zhu X, Lu H, and Rätsch M 2018 An interactive clothing design and personalized virtual display system Multimedia tools and applications. 77(20): pp 27163-179.