

Study on digital textile information and 3D virtual simulation of Chinese Qing Dynasty Lu-silk Apron

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ABSTRACT – REZUMAT

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The Qing Dynasty Lu-silk Apron in the Shanxi Folk Museum is a representative example of the traditional Chinese Apron, with profound cultural and aesthetic connotations regarding pattern type, colour application, and process techniques. Nevertheless, a minimal survey has been done on the Qing Dynasty Lu-silk Apron. The study aimed to discuss the exquisite textile techniques and artistic features of the Qing Dynasty Lu-silk Apron and analyse the social system, humanistic sentiment, cultural symbolism, and intelligent thinking at multiple levels through style types, size analysis, colour interpretation, pattern expression techniques, and skill production. In this article, we also used the popular simulation technology to restore the Qing Dynasty Lu-silk Apron and provide a new way and path to study other ancient costumes.

Keywords: Lu-silk Apron, 3D virtual simulation, traditional clothing, digital textile information, style characteristics

Studiu privind informațiile textile digitale și simularea virtuală 3D a șorțului din mătase Lu din timpul dinastiei Qing din China

Șorțul din mătase Lu din timpul dinastiei Qing din Muzeul Popular Shanxi este un exemplu reprezentativ al șorțului tradițional chinezesc, cu conotații culturale și estetice profunde în ceea ce privește tipul de model, aplicarea culorii și tehnicile de procesare. Cu toate acestea, s-au efectuat foarte puține cercetări asupra șorțului din mătase Lu din timpul dinastiei Qing. Studiul și-a propus să abordeze tehnicile textile rafinate și trăsăturile artistice ale șorțului de mătase Lu din timpul dinastiei Qing și analizează sistemul social, sentimentul umanist, simbolismul cultural și gândirea inteligentă la mai multe niveluri prin tipurile de stil, analiza mărimii, interpretarea culorilor, tehnicile de exprimare a modelelor și abilitățile. În acest articol, a fost utilizată, de asemenea, tehnologia populară de simulare pentru a restaura șorțul din mătase Lu din timpul dinastiei Qing și a oferi o nouă modalitate și cale de a studia alte costume antice.

Cuvinte-cheie: șorț de mătase Lu, simulare virtuală 3D, îmbrăcăminte tradițională, informații textile digitale, caracteristici de stil

INTRODUCTION

Apron is a traditional Chinese underwear, with a strong oriental charm, a long history of culture and exquisite design. The Apron was popular in the Qing Dynasty and became the underwear of the whole people. It can be worn by men, women and children, especially older and children. The most basic function of Apron is to cover the body as underwear. Some Aprons have sewn pockets that can be used to hold personal valuable things (e.g., jewellery or money). In autumn and winter, the cotton or wool fibres can be added to the Apron to sustain warmth. Sometimes, Chinese herbs are put into the Apron, which can be used to cure diseases and keep healthy. The expensive fabrics, such as damask, Luo, silk and satin, are often used to make Apron. In fewer cases, the relatively cheap cotton, linen, home-sick cloth and batik cloth are also used the printed or

embroidered patterns on the Apron are rich and colourful. The majority of the patterns are auspicious, such as "Lotus and Chalder", "Unicorn and Child" symbolizing fertility, "Phoenix and Peony" symbolizing beauty, light and happiness, and so on [1–3]. At present, the research on the Apron in the world mainly focuses on the history, art form, culture, emotion and implication of the Apron [4]. For instance, Li et al. studied the female Apron from the aspects of cutting, pattern decoration and structural form. The design pattern, colour, craft, style and other art elements of the embroidered Apron were analysed and proposed the unique charm of the embroidered Apron [5]. Someone interpreted the artistic characteristics of the Apron under the vision of "aesthetics of artistic symbols". The humanistic emotions contained in the Apron were analysed. Through the above analysis, many Chinese scholars have studied the history, artistic features, design and structure of the belly

band in detail [6]. However, these studies rarely involve the Qing Dynasty Lu-silk Apron, which is the object of this paper and is now collected in the Shanxi Folk Museum. Li et al. analysed the dye composition of the Lu-silk Apron and showed that all the dyes of the Lu-silk Apron were extracted from natural plants, and a variety of different dyeing techniques were used [7, 8]. In brief, there is a lack of research data on this Qing Dynasty Lu-silk Apron.

Therefore, the superb textile

skills and the social background of this Qing Dynasty Lu-silk Apron were studied systematically in this article.

This article studies many aspects of the Qing Dynasty Lu-silk Apron, such as the style, size, fabric, pattern colour composition, pattern theme implication, production technology and so on, based on the image data of Qing Dynasty Lu-silk Apron, combined with a variety of software, from patterns, fabrics, embroidery to clothing, the simulation of Qing Dynasty Lu-silk apron is completed step by step.

MATERIALS AND METHODS

Qing Dynasty Lu-silk Apron

There are two types of belly bands, one is a single piece that covers the front of the chest, and the other is a combination that wraps around the body back and forth. The style of the Qing Dynasty Lu-silk Apron (figure 1, a) is the common type of single piece. The whole fabric of the belly band is cut into a diamond shape. The top corner is cut to form a concave shallow semicircle, and the bottom corner is cut into a sharp shape. This Apron has only the front piece, which is used to protect the belly, without the back piece and two sleeves. When wearing, the belt above the Apron is tied to the neck, the following two sides of the belt can be tied in the waist, and then the Apron covers the front chest to the lower abdomen. Due to the cultural relics were not well protected before they were unearthed, there was a lack of corresponding cloth strips. This Apron not only has the protective function of shielding the chest and abdomen but also conforms to the beauty of human body coordination and symmetry.

The front side of the Qing Dynasty Lu-silk Apron is the jacquard fabric with a star fruit yellow background. A small piece of black satin fabric is stitched into the top corner of the front side fabric, shown in figure 1, a. The front fabric of the Apron is called Lu-silk, which is a famous silk good produced in the Zelu area, Shanxi Province, China. The back of the belly band is brown plain fabric, shown in figure 1, b. There is a colourful embroidery pattern in the middle of the

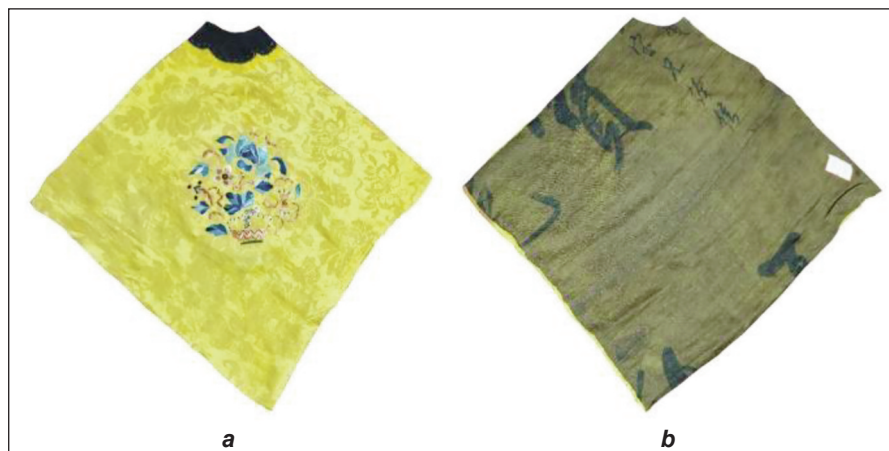


Fig. 1. Qing Dynasty Lu-silk Apron: a – the front of the belly band; b – the back of the belly band

Apron, which is harmonious in colour, delicate in luster, dense in stitches and elegant in appearance.

General scheme

This paper mainly includes two parts. The first part is to study and analyse the artistic characteristics, textile technique and social background, which are reflected by the size, colour, patterns, production technology and structure of the Qing Dynasty Lu-silk Apron. And the digital information of Qing Dynasty Lu-silk Apron is extracted. In the second part, based on the above analysis, a series of software, such as Weaving CAD software, Aarah Weave software, PixPlant software, CLO software, and Sytle 3D software, are used to conduct 3D virtual simulation of Qing Dynasty Lu-silk Apron. The technical road map studied in this paper is shown in figure 2.

RESULTS AND DISCUSSION

Size analysis of Qing Dynasty Lu-silk Apron

The measured size of the Qing Dynasty Lu-silk Apron is 47.5 cm long and 48 cm wide, shown as in figure 3. There is no garment size standard for the Apron worn by the ancient people. To judge the age of the user of this Qing Dynasty Lu-silk Apron, we choose some Aprons with a similar shape, and different sizes and this Qing Dynasty Lu-silk Apron for comparison, as shown in table 1. The length and width are sufficient to characterize the size of the Apron. However, the transverse dimension of the human body is composed of the width of the Apron fabric and the lacing length, even if the same person, the Apron width also has certain differences, so the length of the Apron becomes an important indicator to judge the age of the wearer.

As shown in table 1, seven kinds of Aprons (no. 1–4, 6–8 in table 1) are compared with the Qing Dynasty Lu-silk Apron (no. 5 in table 1). The length of these Aprons is from 25 cm to 60 cm. These Aprons are arranged in ascending order of length. And the users of the seven Aprons (no. 1–4, 6–8 in table 1) have been clear. The analysis shows that the length of children's belly bands is about 35 cm below, and the

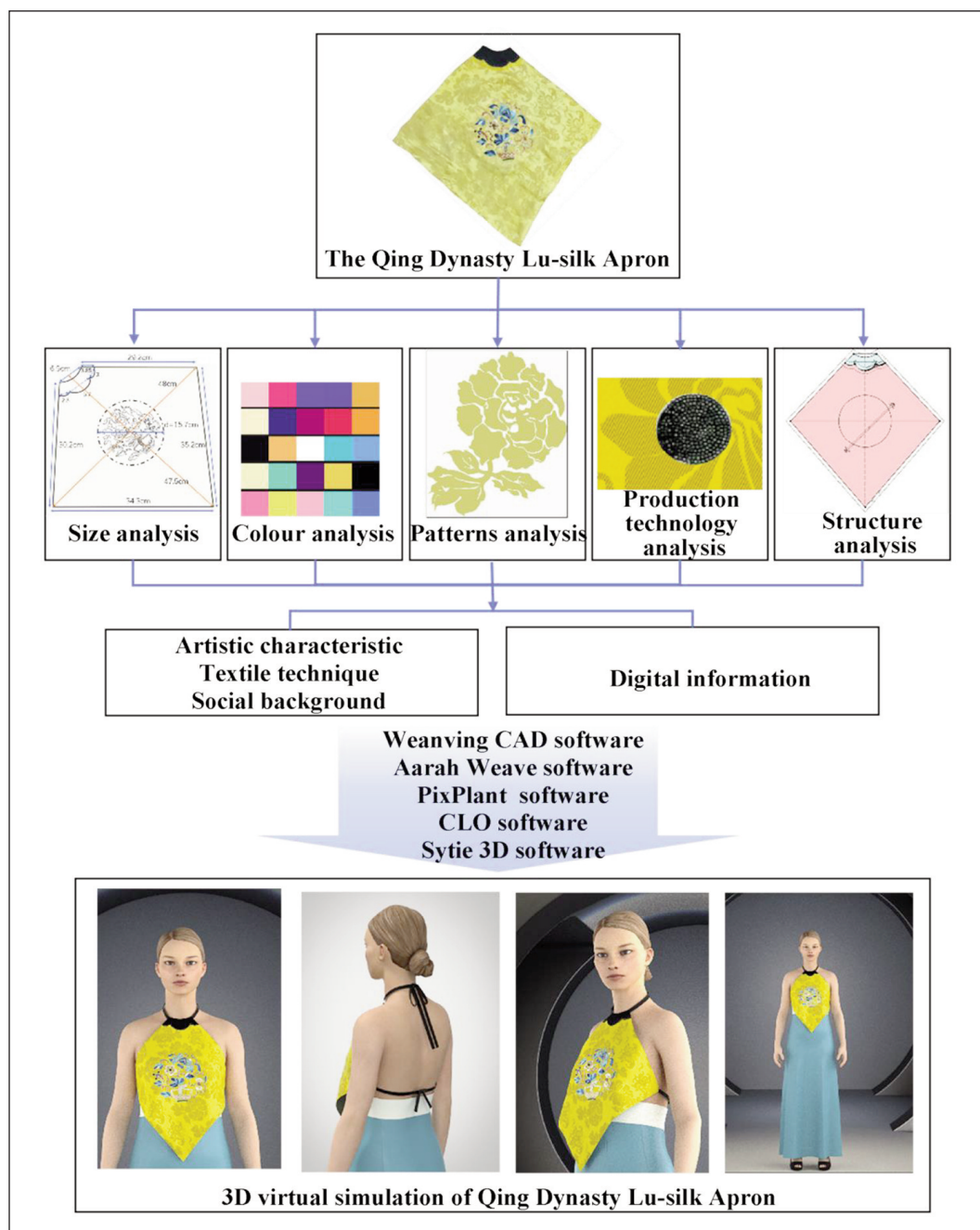


Fig. 2. The general scheme of this paper

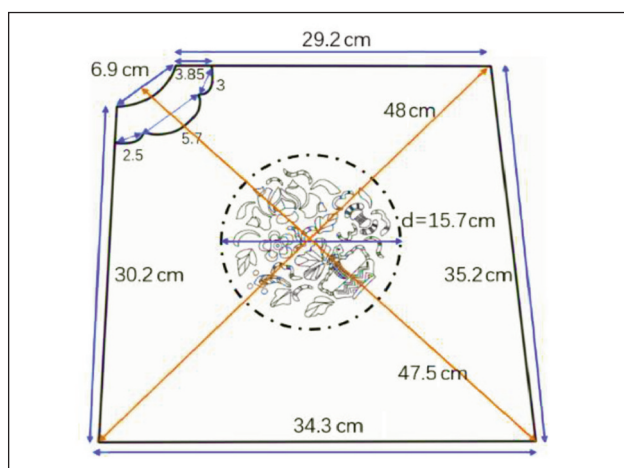


Fig. 3. Dimensional dimension drawing of Qing Dynasty Lu-silk Apron






















length of an adult's Apron is generally 40 cm – 60 cm. Because the length of the Qing Dynasty Lu-silk Apron is about 47.5 cm, it can be preliminarily judged as the Apron used by adult women.

Colour analysis of Qing Dynasty Lu-silk Apron

The colour is an important decorative element in ancient costumes, and each colour has a unique symbolic meaning [9]. We contrasted the colour of the Qing Dynasty Lu-silk Apron with the colour card, and obtained the main colour information, as shown in table 2.

The main colour of the front fabric of Qing Dynasty Lu-silk Apron is carambola yellow, which has medium saturation and high brightness. The colour of the carambola yellow is warm, which can give people a sense of warmth. This colour is bright but not dazzling,

EXAMPLE OF DIMENSIONS OF APRON				
Number	Name	Legend	Size	User
1	The gourd shape apron of blue satin with an applique tiger head		26.4 cm × 24.3 cm	children
2	The embroidered apron of rose pink satin with children holding the longevity peach		35.5 cm × 25 cm	children
3	The embroidery pattern apron of red satin with even the birth of a son		38 cm × 45 cm	adult female
4	The diamond shape apron of blue satin colour embroidery with phoenix plays in the peony bushes		44 cm × 44 cm	adult female
5	The Qing Dynasty Lu-silk Apron		47.5 cm × 48 cm	-
6	The apron of scarlet satin knot stitch with the Kylin sends a son		49 cm × 55.5 cm	adult female
7	The diamond shape apron of blue twill fabric with eight trigrams applique plate gold embroidery characters		55 cm × 49 cm	adult female
8	The diamond shape apron of yuan green satin embroidered with the "Blessed as the East Sea, Longevity as the South Mountain" pattern		60 cm×66 cm	Senior citizens

COLOUR EXTRACTION OF QING DYNASTY LU-SILK APRON				
Serial number	Colour name	Colour chart	(R, G, B)	(H, S, B)
1	Carambola yellow		(246,240,132)	(57,46,96)
2	Azurite blue		(175,221,224)	(184,22,88)
3	Gainsboro		(165,191,194)	(186,15,76)
4	Indigo		(0,123,187)	(201,100,73)
5	Brown		(141,80,25)	(28,82,55)
6	Ochre		(173,104,61)	(23,65,68)
7	Emerald Blue		(0,164,197)	(190,100,77)
8	Magenta		(0,107,148)	(197,100,58)
9	Aqua Blue		(89,195,225)	(193,60,88)
10	Sailor Blue		(0,69,122)	(206,100,48)
11	Pure blue black		(0,0,34)	(240,100,13)
12	Silvery white		(225,222,210)	(48,7,88)
13	Parrot green		(0,100,60)	(156,100,39)
14	Indigo		(0,46,90)	(209,100,35)
15	Flower light onion		(0,142,165)	(188,100,65)
16	Saddle brown		(82,51,17)	(31,79,32)
17	Red hinoki skin		(127,76,68)	(8,46,50)
18	Jade white		(253,252,243)	(54,4,99)
19	Orange		(191,161,116)	(36,39,75)
20	Blanched almon		(250,206,157)	(32,37,98)
21	Black		(24,17,15)	(13,37,9)

which is not only elegant and auspicious but also elegant, showing the user's aesthetic interest.

The embroidery patterns (figure 4) located in the centre of the Qing Dynasty Lu-silk Apron and mainly used different shades of blue embroidery thread. Many parts of the embroidery have obvious characteristics of three blue embroidery, which is embroidered using many (at least 3) shades of blue threads. The overall colour of the embroidery is simple and elegant.

Some cool colours in embroidery patterns, such as bluish porcelain, Gainsboro, indigo, emerald blue, magenta, aqua blue, sailor blue, pure blue-black, parrot green, indigo and flower light onion, are used as contrasts. These cool colours are matched with the warm colour of carambola yellow to form a contrast between warm and cold colours, making the picture more profound and vivid. In terms of colour saturation, some colours used in embroidery patterns, such as Gainsboro, brown, emerald blue, magenta, aqua blue, sailor blue, pure blue-black, silvery-white, parrot



Fig. 4. The embroidery patterns in the centre of Qing Dynasty Lu-silk Apron

green, indigo, flower light onion and saddle brown, are highly saturated, which is more vibrant under the foil of the yellow background fabric. All colours in the embroidery pattern of the Qing Dynasty Lu-silk Apron include 55% cool tones and 45% warm tones; 20% low saturation colour, 30% medium saturated colour and 50% high saturated colour; 15% low brightness colour, 35% medium



Fig. 5. Colour distribution chart

brightness colour and 50% high brightness colour. The distribution of colours is shown in figure 5. In this way, through the adjustment of saturation and brightness, and the collocation of warm and cold colours, the picture of the embroidery pattern is more colourful and vibrant.

Patterns analysis of Qing Dynasty Lu-silk Apron

Jacquard fabric pattern

The pattern of the Apron is one of the important elements that affect the artistic beauty of the Apron, including the theme, composition, arrangement and so on. The front of the Qing Dynasty Lu-silk Apron is a jacquard fabric, and there are three jacquard patterns, as shown in table 3.

The first is the butterfly pattern (table 3) with an 8.8 cm length and 6.5 cm height, which is arranged from

Table 3

JACQUARD DARK PATTERN OF QING DYNASTY LU-SILK APRON		
Format	Dark pattern diagram	Extraction chart
Butterfly		
Chrysanthemum		
Peony		

the top left to the bottom right on the Apron. One of the Chinese homonyms for the butterfly pattern is the word “臺”, which symbolizes good luck and long life. Another Chinese homonym for the butterfly pattern is the word “飀”, which has a good implication for children and grandchildren, prosperity and prosperity. The butterfly pattern is a common insect pattern in traditional clothing.

The second is the chrysanthemum pattern (table 3) with 9.5 cm length and 11 cm height, which is also arranged from the top left to the bottom right on the Apron. In Chinese culture, the chrysanthemum, plum blossom, orchid and bamboo are known as the “four gentlemen” among flowers. The chrysanthemum pattern symbolizes purity and longevity and is a favourite decorative subject of the literati.

The third is the peony pattern (table 3) with 9 cm length and 10.5 cm height, which is also arranged from the top left to the bottom right on the Apron. The peony is called the king of flowers in Chinese culture and has a meaning of luxury.

These three patterns, including butterfly, chrysanthemum and peony, are combined and form a circulation unit with 9 cm width and 27.5 cm height, as shown in figure 6, *a*. The circular arrangement of three patterns, which has a more unique creativity, is shown in figure 6, *b*. Three patterns, covered the whole Apron, possess a vivid and flowing feeling and stable, balanced visual effects. The combination of butterfly pattern and plant patterns has the cultural implication of marriage happiness, prolongation of children and good fortune.

Embroidery pattern

There is an embroidery pattern as shown in figure 7, *a* in the centre of the Qing Dynasty Lu-silk Apron. We use the virtual simulation digital technology to extract the embroidery pattern [10–12], as shown in figure 7, *b*. The embroidery has a good effect of decoration and embellishment on the overall visual effect of the Apron [13]. The embroidery produces colour brightness and shade in visual form and shows harmonious beauty.

The shape 1 in the embroidery pattern is a blue lotus flower. In ancient China culture, the blue lotus flower means “a baby for everybody” and “rich and have a

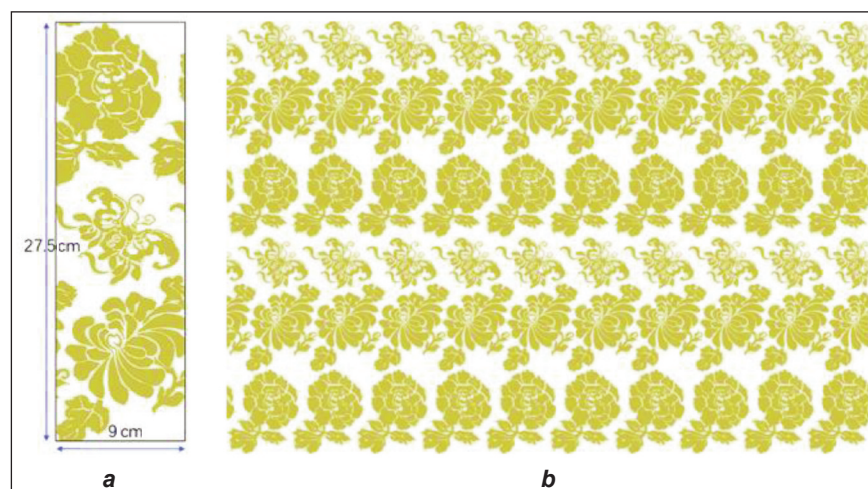


Fig. 6. Pattern simulation drawing: *a* – circulation unit; *b* – pattern circulation diagram

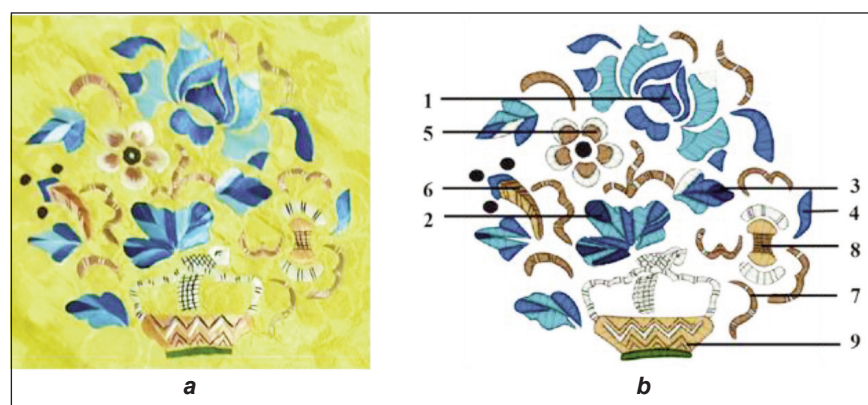


Fig. 7. Embroidery pattern of Qing Dynasty Lu-silk apron: *a* – physical pattern drawing; *b* – simulated pattern

surplus”. This reflects the ancient people's expectation of generations and family prosperity.

Drawing the shape 2 in the embroidery pattern is a relatively complete lotus leaf. The shape 4 is a petal from a lotus flower. The shape 3 is a small part of the lotus leaf, and the similar lotus leaf shapes appear in many places in the embroidery patterns. The colour of the three shapes 2, 3 and 4 are blue series, which echoes the blue lotus flower (shape 1). In this way, the combination of lotus flower and lotus leaf symbolizes the vitality of luxuriance and flourishing.

The shape 5 in the embroidery pattern is a plum flower with five petals and a graduated colour. In Chinese folk culture, the five petals of the plum flower mean the five blessings of fortune, emolument, longevity, happiness and property. The plum begins to blossom in the cold time and opens before the other hundred flowers, so the plum in ancient times is also known as “winter jasmine”, which means to welcome spring.

The shape 6 in the embroidery pattern is an ear of grain. In ancient China's farming era, only the agricultural harvest could lead to a rich life, so the ears of grain meant a good harvest in agriculture.

The shape 7 in the embroidery pattern is a spring grass-like dogwood. This spring grass pattern

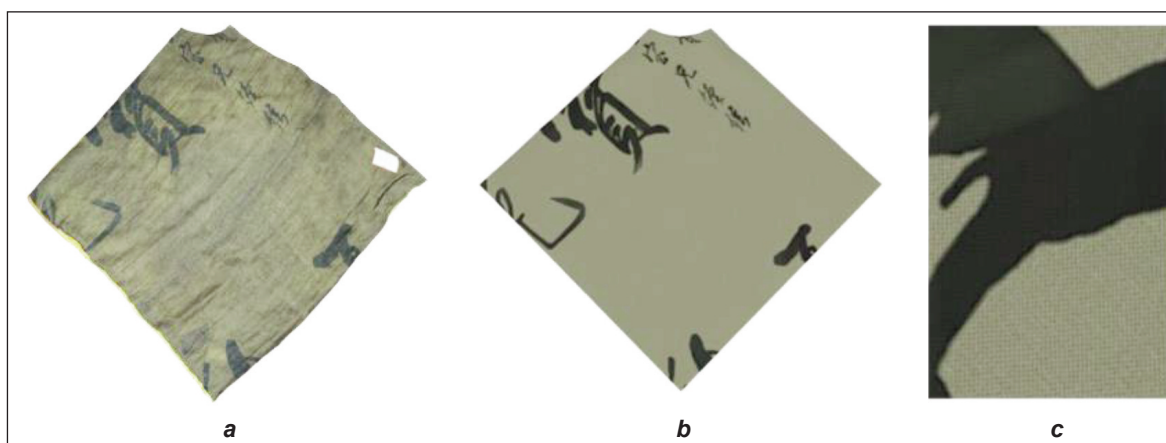


Fig. 8. Ink writing pattern on the back of Qing Dynasty Lu-silk Apron: *a* – back side physical picture; *b* – back side simulation pattern; *c* – texture detail

appears in many places in the embroidery part of the Qing Dynasty Lu-silk Apron. These grass grain patterns, which have various shapes, are the embellishment of the overall embroidery pattern. In addition, these grass grain patterns symbolize life and prosperity.

The shape 8 in the embroidery pattern is a gold ingot, which is a symbol of money and wealth. The gold ingot pattern comes from the beautiful form of gold and silver ingots, meaning wealth and richness.

The shape 9 in the embroidery pattern is a bamboo basket. On the top of the bamboo basket, there is an abstract baby shape, which means early birth, many children and good fortune. The bottom of the basket looks like a pottery basin, with many zigzag polylines as decoration. From the perspective of the whole embroidery pattern, all the beautiful and auspicious patterns are located around and above the bamboo basket, so that the bamboo basket has the meaning of a cornucopia.

The whole embroidery pattern included images of spring grass, summer lotus, autumn grain, winter plum, wealth and prosperity and baby, which symbolize good luck, longevity and fertility.

Ink writing pattern on the back of Qing Dynasty Lu-silk Apron

The back of the Apron is a brown plain fabric. There is ink writing on the fabric, as shown in figure 8. The ink writing means to congratulate the older brother, whose name is Bao, on “renewed string”. In China ancient times, couples were compared to harps. The death of the wife was called “broken string”, and the husband remarried after the death of the wife was called “renewed string”. From the meaning of the ink writing can be speculated that this Lu-silk Apron may be a remarriage gift to celebrate a male friend.

The sizes of the ink words are different, and some words are incomplete or missing. It is speculated that the gift first tattooed the ink writing on a piece of brown plain fabric, and then cut the fabric for making the Apron. Because the used fabric was limited, the ink writing could not be completely presented, so some words were incomplete or missing.

Production technology analysis of Qing Dynasty Lu-silk Apron

The embroidery methods include flat needle embroidery, seed embroidery, three blue embroideries, plate gold embroidery and so on [14]. The Lu-silk Apron was embroidered by flat needle embroidery. The characteristics of plain stitch embroidery are that the needle tracking is straight, and the embroidery threads are neatly and evenly covered on the surface of the fabric, without revealing the background colour or overlapping each other, so the embroidery surface is very flat, which can show the luster of silk. Different colours of threads, such as blue, orange, brown, pink, white and black, are used in the embroidery process.

The plain needle embroidery used in this Lu-silk Apron includes two kinds: the straight needle and the upright needle. The outgoing and incoming stitches of the straight needle embroidery as shown in figure 9, *a* are at the edge of the pattern, which has an even surface effect. The upright needle embroidery as shown in figure 9, *b* is embroidered in layers according to the pattern shape, that is, from the outer edge to the inner layer. The thread colours of the upright needle embroidery are from light to deep, so the embroidered pattern has an excellent shade-colour effect.

Besides the plain needle embroidery, the seeding needle embroidery as shown in figure 10 is also used

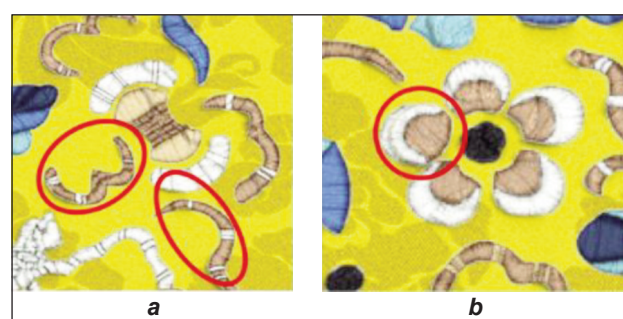


Fig. 9. The plain needle embroidery: *a* – the straight needle embroidery; *b* – the upright needle embroidery

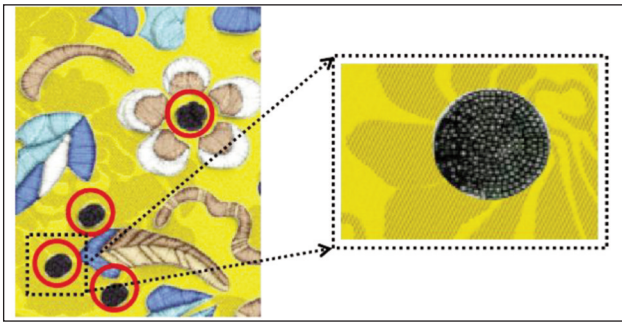


Fig. 10. The seeding needle embroidery

in the Lu-silk Apron. The seeding needle embroidery is also called “knop embroidery” or “ring embroidery”. The specific embroidery method is to pull clasps on the embroidery ground, to produce small ring knops like seeds or pearls. The seeding needle embroidery has a three-dimensional sense and is often used to show the texture of embroidery, the stamens of flowers and the eyes of animals, etc.

The Qing Dynasty was the peak period of the development of Chinese embroidery skills. The embroidery technique of the Lu-silk Apron is exquisite,

which shows the delicacy of ancient women's hand-crafts.

Structure analysis of Qing Dynasty Lu-silk Apron

The structure of the Lu-silk Apron consists of three main parts as follows: the front of the Apron is made of Lu-silk fabric with a carambola yellow background, a small piece of black satin fabric pieced on the top corner and the brown plain fabric on the back.

It is found that the outer profile of the Qing Dynasty Lu-silk Apron is asymmetrical. It is possible that this silk Apron has not been properly preserved, and may have been suspended or pulled to cause large deformation. The original structural dimension of the Lu-silk Apron was measured as shown in figure 11.

To explore the appearance of the Apron before deformation, we used Clothing CAD Software to correct the structure drawing and the sample plate drawing [15–17]. Comparing the Apron patterns before and after correction, the red-shaded part is the corrected Apron pattern. Through comparison of contour lines, the adjustment and change of each position in the Apron pattern can be observed as shown in figure 12.

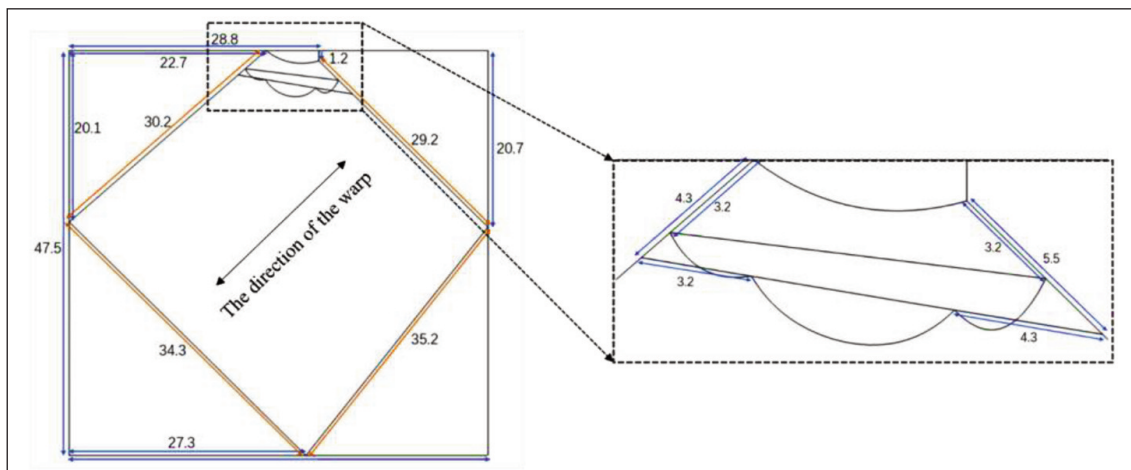


Fig. 11. The original structure of the Qing Dynasty Lu-silk Apron

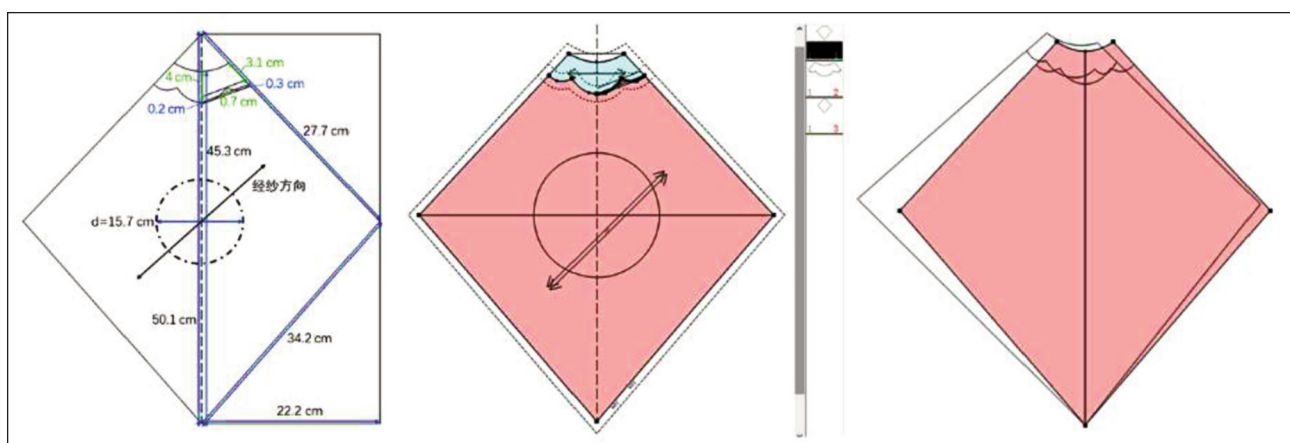


Fig. 12. The corrected structure of Qing Dynasty Lu-silk Apron: *a* – structure drawing; *b* – sample plate drawing; *c* – compared the apron version patterns before and after correction

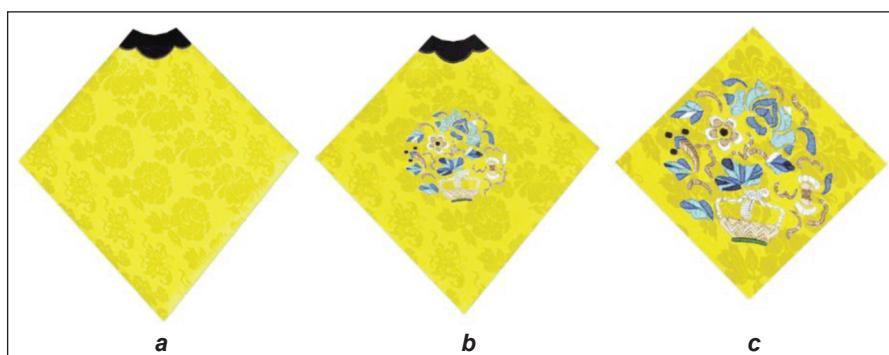


Fig. 13. Final virtual simulation diagram: *a* – fabric simulation diagram; *b* – overall effect pattern; *c* – embroidery details pattern

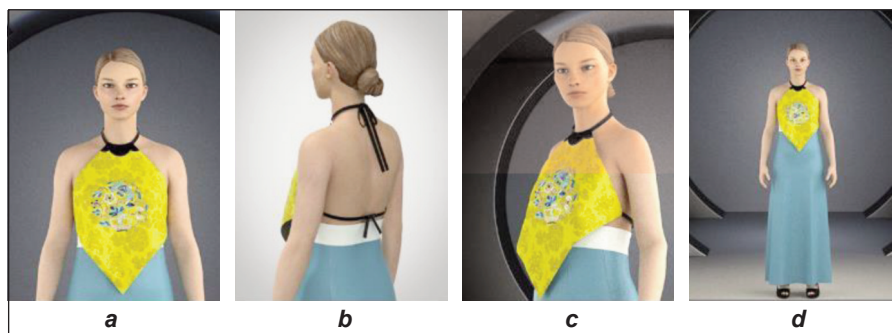


Fig. 14. Clothing wearing effect display: *a* – front; *b* – back; *c* – side; *d* – whole body

CONCLUSION

Through the pre-fitting correction, we used a series of drawing software to virtually simulate the garment, such as Weaving CAD software to get the resulting pattern file and be used for weaving fabrics in an electronic jacquard machine, the Aarah Weave software obtains a simulation of the pattern, PixPlant software extracts the textures, CLO software enriches fabric details, Sytle 3D software creates embroidery simulations, for some defects that need to be adjusted and fixed in Photoshop, thus, the whole process will complete the simulation of the Lu-silk Apron as shown in figure 13.

At last, we showed a mock display of the costumes, the Lu-silk Apron relic does not have a tie, to facilitate the mannequin to simulate the wearing effect, a pair of ties were sewn at the neck and waist, and the colour of the tie is consistent with the shallow recess at the upper end of the belly pocket, all in black, which can echo each other. Then, in the stage scene and animation mode that comes with CLO 3D software [18, 19], let the model show the costume on the catwalk according to the specified route, and capture

the front, back, side and body clothing display renderings as shown in figure 14 below.

In the final simulation rendering, we can see that the simulated Qing Dynasty Lu-silk Apron is bright and shiny, and the dark lines on it are visible, with natural bending and drape effects. And the embroidery part has an obvious three-dimensional texture, and the embroidery thread has distinct colours and a strong sense of luster.

To inherit and develop Chinese historical and cultural heritage, this paper takes the costumes in the ancient clothing of the Qing Dynasty Lu-silk Apron as the research object. Based on the analysis of the culture and characteristics of the costumes, we used modern digital simulation technology to draw the dark jacquard pattern, embroidery pattern and back pattern of the Lu-silk Apron fabric. In addition, considering the fading of the Qing Dynasty Lu-silk Apron

colours and the deformation of styles, its shape and colour were corrected, based on the Qing Dynasty Lu-silk Apron, as cultural relics it has been reproduced restoratively through computer software so that it is presented in a new and more detailed appearance. In the era of advanced information technology, Chinese traditional clothing is loved by more and more people, we should inherit and carry forward clothing culture, it will show the artistic value of Chinese clothing and the charm of national culture and promote the excellent historical culture of China, and provide a new way and path to study other ancient costumes.

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