

Compound Half-Backed Weave Design For Digital Jacquard Fabric

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Abstract: Based on layered-combination design mode and compound structure, this paper presents a design method, named compound half-backed weave in order to achieve innovating weave structure and surface effect of fabric. This design method includes primary weaves chosen, half-backed technical points set up and half-backed weave databases established. The fabric produced using compound half-backed weave designed by this method can exhibit a unique half-backed effect that only half of the threads on the fabric surface remain in a state of being covered by adjacent wefts. Compound half-backed weave can not only meets the design need of jacquard fabric with different digital images and effectively improves the efficiency of structural design, but also puts forward new theory and method for innovative design of digital jacquard fabric.

1. Introduction

Jacquard woven fabric is made from dyed yarns and different weaves [1, 2]. It exhibits complex pictorial patterning effects on the face of fabrics and is one of the most value-added textile products [3]. The design process of traditional jacquard fabric is divided into three steps. First, a colourful pattern is drawn freehand. Then, the weave structure of jacquard fabric is designed to copy the effect of original pattern. Lastly, a weaving pattern is exported in jacquard CAD to control a jacquard loom and the jacquard fabric with the freehand pattern would be produced [4, 5]. Since consumers selected fabric firstly depending on their visual images on the face of fabric [6-8], it is important for designers to produce jacquard fabric with exquisite effect and abundant colours. However, the design cycle must last long. The design of layered-combination design mode and compound structure make digital images can be used directly in jacquard fabric design and shorten the pattern and technical designing time [9, 10].

Previous research works of layered-combination design mode, of which the key technology is the innovation of structure design, indicated that the compound structures can be divided into three basic types (figure1): backed, unbacked and half-backed [11]. The backed structure is a kind of compound structure being employed normally on design of conventional weft-backed fabric. The weft with longer float length cover the other one and only the colour information of the weft with longer float length is on the fabric surface [12, 13]. The unbacked compound structure, which can only be used on layered-combination design mode, is capable of expressing mixture colours accurately. There is no relationship among adjacent two wefts and the colour information of all wefts is on the fabric surface [4]. The theoretical and practical researches of unbacked compound structure, so called full-colour compound structure, have been introduced in the previous studies [14]. Several innovative design



works of digital jacquard with millions of mixed colours and various pattern motifs have been produced using full-colour effect compound structure, including simulation effect, superimposition effect, double-face effect, shot-effect, etc [14]. However, the half-backed compound structure is that each weft could be covered only by either the upper or the lower adjacent weft. An innovative method of compound structure, here called the compound half-backed weave design, based on the structural characteristics of the compound half-backed weave, is presented in this paper.

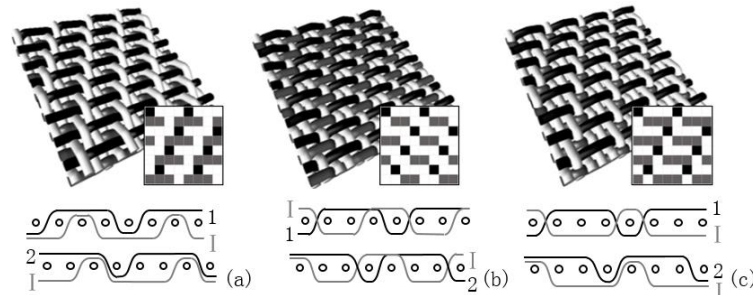


Figure 1. Compound structures design with two wefts: (a) Backed, (b) Unbacked, (c) Half-backed.

2. Design Principle and Method of compound half-backed weave

2.1. Design Principle of compound half-backed weave

Similar to the design method of compound full-colour weave, according to the feature of compound structures, the single weaves used for combination are called primary weaves [4]. Design principle and process of compound half-backed weave are as follows: in the wake of primary weaves chosen; half-backed technical points are set up for each of them; two series of shaded gamut weaves, named basic weaves and joint weaves, are established by enhancing weave points on two primary weaves without destroying half-backed technical points (figure 2). The combination of any single weave from basic weaves and another one from joint weaves has the characteristic of compound half-backed weave that do well out of the half-backed technical points. The half-backed technical points, resemble a kind of weave, are assembling of the weave points that make the combination of single weaves meet the requirements of half-backed effect. The fabric produced by this compound structure could express unique half-backed effect in which only half of the threads were covered by each other.

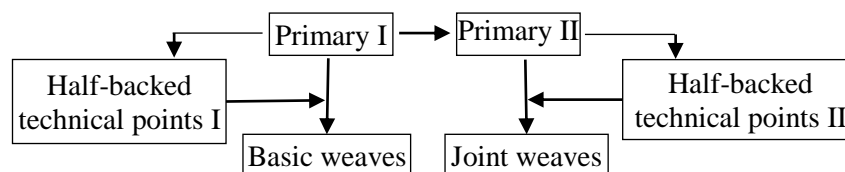


Figure 2. Design process of compound half-backed weave.

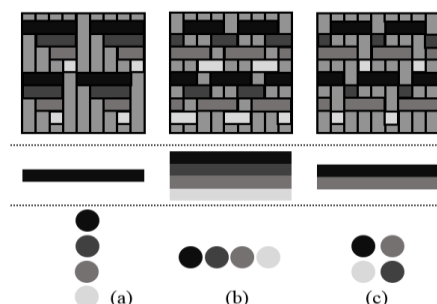


Figure 3. Mixed colouring with four wefts compound structure: (a) Backed, (b) Unbacked, (c) Half-backed.

Colouring effect on fabric surface is colour mixing of limited opaque colours. People only can get the mixing effect but the single colour from a normal distance [4]. The colour mixing is realized by

interweaving warp and weft, and the colour proportion of yarn is decided by float length, which is to say, the colour proportion of yarn is decided by weave structure. Since compound half-backed weave is consist of at least two single weaves, even wefts are needed in half-backed effect jacquard design. With two wefts, the surface effect of backed structure is the same with the one of compound half-backed weave, so four wefts are the least in the application of compound half-backed weave. The colour mixing principle with four wefts is shown in figure 3. Weave structures, surface visual effect and covered relationship among wefts are shown from top to bottom.

2.2. Design Method of compound half-backed weave

According to the design process (figure 2), compound half-backed weave design method can be divided into four steps: choosing primary weaves, designing half-backed technical points and establishing compound half-backed weave.

Choosing primary weave I is similar to the compound full-colour weave design method, and twill and sateen both can be primary weaves. But primary weave II must be fixed and immovable when primary weave I is selected in the method presented here. 8-thread sateen, taken as an example, figure 4 shows the selection of primary weave II: primary weave I themselves, the derivative weaves of the primary weaves I, and the combinations of primary weave and derivative weaves are listed from top to bottom. Primary weave I is 8-thread weft-faced sateen, which provides seven weave variations through moving the starting point of the primary weave I. The eight derivative weaves (including the primary weave I) can generate eight combinations with the primary weave I in the form of 1:1 along weft direction. Only two combinations can satisfy the half-backed structural characteristics that each weft in a compound weave should in a covered relationship with at least one juxtaposed weft. When primary weave I is selected, primary weave II must be a weave shifted up one weft yarn from primary weave I or be a same weave with primary weave I. To control an appropriate length of floats on fabric surface, the best repeat range of primary weave should be between 5×5 and 48×48 .

In compound half-backed weave design part, 16-thread sateen served as an example. As shown in figure 5, two primary weaves and their half-backed technical points were established. Primary weaves were selected using the same weave repeat of warp and weft. Primary weave II is the one shifted up one weft yarn from primary weave I. Then reverse the interlacing points on primary weaves I. The two interlacing points were strengthened upwards and downwards simultaneously, and half-backed technical points I were set by reversing the previous weave points again. Half-backed technical points II were set using the same method.

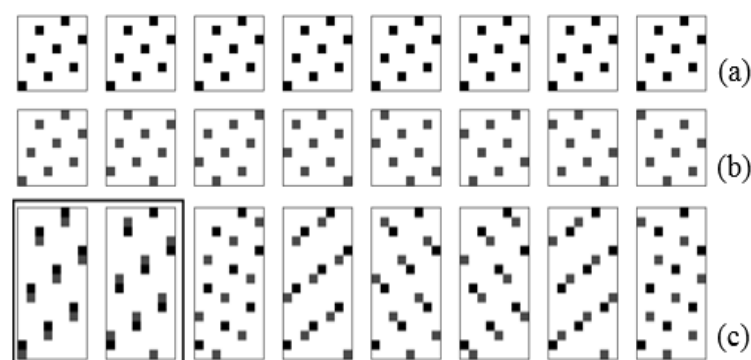


Figure 4. Selection of primary weave II: (a) Primary weave I; (b) Derivative weaves; (c) Combinations.

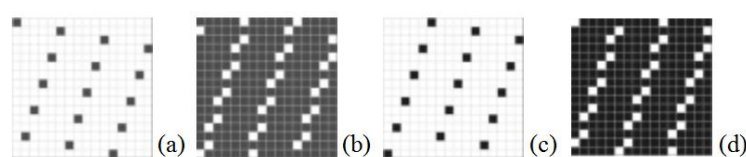


Figure 5. Primary weaves and their half-backed technical points: (a) Primary weave I, (b) Half-backed

technical points I, (c) Primary weave II, (d) Half-backed technical points II.

After confirming two primary weaves and their half-backed technical points, a series of gamut weaves, called basic weaves, were designed by reinforcing interlacing points step by step without destroying the half-backed technical points I upon the primary weave I. Another set of gamut weaves, called joint weaves, were designed in the same way upon the primary weave II. Figure 6 shows the impound half-backed weave when the enhancement number of shaded interlacing points is 16.

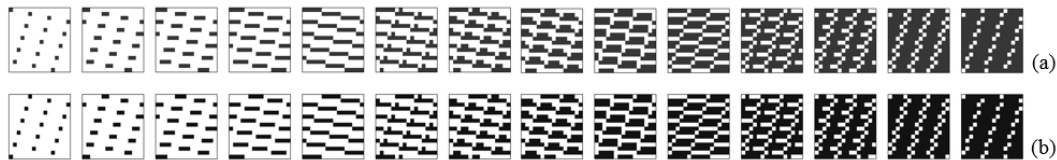


Figure 6. Compound half-backed weave: (a) Basic weaves, (b) Joint weaves.

These two series of weave can be used to design digital jacquard fabric with two wefts directly, and they also can be used to design fabric with four wefts by combination and separation (figure 7): basic weave and joint weave are combined in the form of 1:1 along weft direction, then disassemble the combination in form of 1:1:1:1 along weft direction into four weave databases used for jacquard with four wefts design. To paraphrase this method, Basic weaves can be turned into two weave databases, here called basic weave database I and basic weave database II designed by disassembling the odd wefts and even wefts from basic weaves. Similarly, joint weave database I and joint weave database II also can be established via the same way from joint weaves (figure 8).

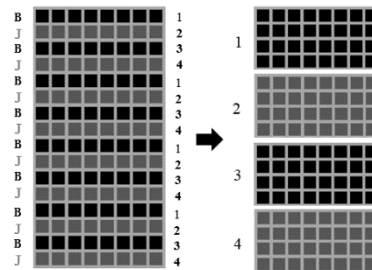


Figure 7. Combination and separation of weave databases.

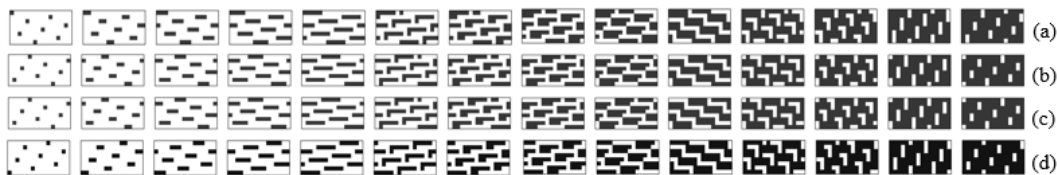


Figure 8. Compound half-backed weave databases: (a) Basic weave database I, (b) Basic weave database II, (c) Joint weave database I, (d) Joint weave database II.

3. Application of compound half-backed weave

The key technical parameters of fabric are detailed in the technical specification table (table 1). A set of 22.2/24.4dtex \times 2 warp silk yarns in white and four sets of 22.2/24.4dtex \times 5 weft silk yarns in earthy yellow, grass green, black, and orange respectively are used to produce half-backed jacquard fabric in this paper.

In the design process of half-backed jacquard fabric, firstly pattern design need to be separated into four colour layers. Since the brightness of gray scale serves as the basic parameter for correspondence of weaves¹³ and one to one corresponding principle is indispensable for jacquard fabric, gray scale processing is necessary to taken in Photoshop to reduce the colour gradations less than or equal to the weave numbers of database. The first single-layer structure can be formed by the one-to-one correspondence between the first layer's gray gradations and basic weave-database I in jacquard CAD system. The second, third and fourth single-layer structures can be formed by joint weave-database I,

basic weave-database II and joint weave-database II, respectively. Then, the compound fabric structure is combined by these four single-layer structures in 1:1:1:1 order along weft direction. Figure 9 illustrates that the one with four layers.

Table 1. Technical specification of half-backed fabric with four-layer fabric structure

	Parameters	
	Warp	Weft
Materials	22.2/24.4dtex \times 2 (white)	22.2/24.4dtex \times 5 (cyan/magenta/yellow/black)
Density	114 threads/cm	100 threads/cm
Composition	Silk 100 %	
Weave structure	16-thread gamut weaves, 14 gray grades	
Design repeat	2400 needles \times 2624 fillings	
Pattern repeat	21 cm (width) \times 26.4 cm (length)	

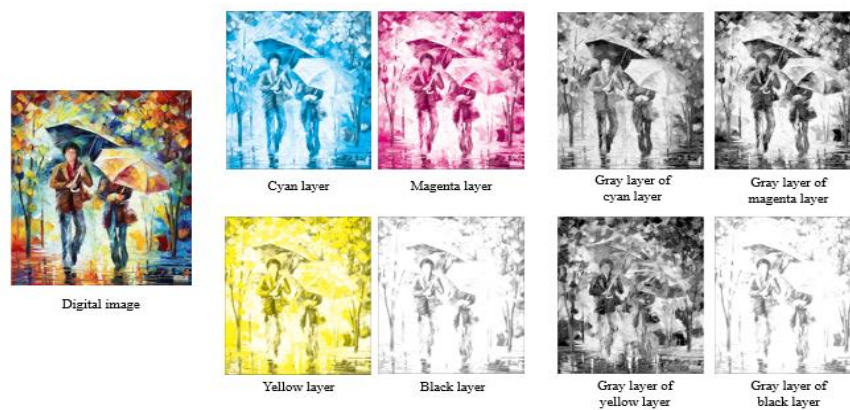


Figure 9. Digital image with four layers.



Figure 10. Compound fabric structure and half-backed jacquard fabric: (a) Compound fabric pattern; (b) Fabric effect; (c) Details of fabric.

The jacquard fabric with half-backed effect can be produced directly on a loom controlled by the compound fabric structure. Figure 10 presents the design effect of compound fabric structure, real fabric and detailed smooth shading effect. Only half of the threads are covered at random on the fabric surface due to the existence of half-backed technical points. Each weave database has 14 weaves means every single layer has 14 colour, so the fabric with four layers can express $14 \times 14 \times 14 \times 14 = 38416$ colour mixing effects on fabric surface that only can be realized in the layered-combination design mode. The other designers cannot copy the pattern and colour effect of the fabric accurately only on the basis of the surface features of final fabric. Therefore, such method proposed in this paper can help designers keep off the piracy in the technical level, and promote the value-added of digital jacquard fabric greatly.

4. Conclusion

This study of compound half-backed weave is a kind of design researches in the field of digital structure innovation of jacquard textile under the layered-combination design mode. The design of

compound half-backed weave should be approached on the base of gamut weaves and its half-backed technical points. Once the weave databases were set up, it is timesaving for designers do not need to design weave-databases every times and it can be used in every design procedure. The fabric designed with compound half-backed weave design is capable of expressing random half-backed colour mixture effect and can present million-level mixed colours by only four sets of weft. It is much easier than the traditional method that using eight sets of wefts. And the fabric that produced in this way only can be realized under the layered-combination design mode, so it is effective for protecting the designers' copyright. It is envisaged that the fabrics produced by compound half-backed weave meet well the technical requirement of balanced interlacement and pose no problem in mass production.

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