

Research on Innovative Design Methods of Intangible Cultural Heritage in Leather Products: A Case Study of Miao Cross-Stitch Patterns in Guizhou, China

by

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Abstract

Intangible cultural heritage is an important symbol of a nation's historical and cultural achievements, containing rich connotations and high artistic value. Leather products, as a significant component of modern fashion, have a wide range of market demand. To address the issues of traditional patterns in intangible cultural heritage not matching modern aesthetics and lacking application scenarios, this study takes leather products as carriers and proposes an innovative design paradigm for traditional clothing patterns. We chose the Miao cross-stitch patterns of Guizhou, China, as a case study. Analyzed their subject connotations, common structures and features. Using split grammar and shape grammar, the patterns are deconstructed and reassembled to obtain foundational innovative patterns. The Mean-shift clustering algorithm was applied to extract the classic colors of Miao cross-stitch patterns. Based on fractal theory and computer algorithms, a novel pattern model for Miao cross-stitch was proposed, incorporating representative patterns and colors to complete pattern designs. Finally, the feasibility of the proposed approach was validated through the practical design of leather fashion accessories on the Style 3D platform. This study aims to provide methodological references for the modernization and innovation of intangible cultural heritage, as well as the diverse integration of leather products design.

1 Introduction

Guizhou Miao cross-stitch is a traditional folk craft and one of China's intangible cultural heritages. Miao cross-stitch patterns hold unique ethnic spirit and rich cultural connotations. Cross-stitch involves picking out regular patterns with colored silk threads on a hessian backing. It is popular for its intricate and delicate features.¹ However, with the rapid development of society and changes in the general public's aesthetic preferences, the Miao cross-stitch craft is gradually facing challenges due to its low production efficiency and strong subjectivity.² Traditional Miao cross-stitch patterns struggle to meet the current aesthetic demands. It has become a major

challenge to make Miao cross-stitch retain the essence of national culture while meeting modern aesthetic standards and adapting to the needs of social development.

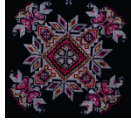



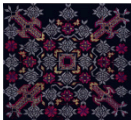

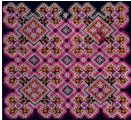
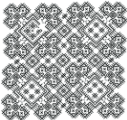






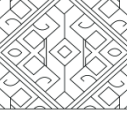


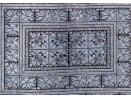
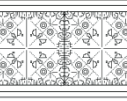
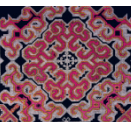



Compared to other materials such as textiles and ceramics, leather can better meet consumers' demands due to its excellent elasticity, durability and malleability. It has gradually become an essential component in the modern fashion industry and is widely applied in clothing, footwear, household goods and other fields. Applying innovative Miao cross-stitch patterns to leather products is beneficial for enhancing the added value and cultural attributes of leather goods, further expanding their market share. Therefore, exploring innovative design methods for Miao cross-stitch patterns in leather products not only holds significant cultural value but also carries practical significance for the inheritance and innovation of traditions.

In 2003, United Nations Educational, Scientific and Cultural Organization promulgated the "Convention for the Safeguarding of the Intangible Cultural Heritage", which explicitly recognizes that intangible cultural heritage is an important factor in defining cultural characteristics, stimulating creativity and safeguarding cultural diversity. It plays an irreplaceable role in promoting mutual tolerance and harmony among different cultures.³ Consequently, the importance of safeguarding intangible cultural heritage has been increasingly recognized internationally, leading to extensive academic attention and practical exploration.⁴⁻⁸ Among them, the integration and development of intangible cultural heritage with industries such as fashion and design have emerged as new trends in practice and research.⁹⁻¹³ The rapid development of science and technology has provided new possibilities for artistic expressions. Thanks to mathematical models, big data statistics and computer algorithms, valuable research outcomes have emerged in the related fields. Ding XJ started from the structure and characteristics of "She" ethnic clothing, summarizing the pattern features and spatial distribution characteristics. Combining the Bag of Visual Words model and K-means clustering algorithm, they proposed an automatic classification and redesign model for "She" ethnic

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Manuscript received September 15, 2023, accepted November 9, 2023.

Table I
Classification and extraction of Miao cross-stitch patterns.

Category	Name	Actual Image	Line Drawing Extraction	Meaning
Plant motifs	Eight-petal flower			Local wild plants and flowers have auspicious meanings of warding off evil and bringing good luck.
	Pomegranate flower pattern			It signifies the pursuit of good things.
	Peony flower pattern			The local people believe that peony flower comes from the place where their ancestors once lived, expressing their nostalgia for their homeland.
Animal motifs	Fishbone pattern			The fishbone flower is one of the most representative basic motifs of the region.
	Butterfly pattern			The Miao people believe that butterflies evolved from maple wood and hatched the ancestors of humans.
	Frog pattern			Frogs, known for their strong survival and reproductive abilities, are considered symbols of gods by the Miao people.
Geometric motifs	Labyrinth pattern			They carry the meaning of wealth and good fortune.
	Rhombus pattern			Representing resilience, with the connotation of warding off evil and bringing good luck.
	cross-hatched pattern			They carry the meaning of joy and auspiciousness.
Other motifs	Silver hat flower pattern			Similar to the flowers on a silver hat, they mainly represent blessings and prayers for safety.
	Snowflake pattern			Based on the snowflake, this pattern has a neat and rigorous design, depicting the weather.
	Jar bottom flower pattern			It expresses a longing for a better life.

clothing.¹⁴ Wang TX focused on textures and used ResNet to establish an image recognition model for willow weaving textures. They also proposed a deep learning-based willow weaving texture design method based on deep convolutional generative adversarial networks.¹⁵ Ding N addressed the complex pattern elements in Miao wax-resist dyeing, a non-material cultural heritage in Guizhou, China. They proposed an ethnic pattern redesign method based on improved shape grammar and optimization algorithms.¹⁶ Ju F started from colors and used ancient embroidery patterns on Chinese traditional garments as their study subject. Based on K-means++ clustering and the Canny operator, they introduced an intelligent color and contour recognition method capable of accurately identifying colors and contours of intangible cultural heritage embroidery images.¹⁷ Nevertheless, researchers have mostly focused on one specific aspect of structure, texture, element, color, etc. when exploring the content of innovative design. Few researchers have approached the subject from multiple angles and proposed a more comprehensive pattern innovation design system.

For this purpose, this study was carried out as follows: Taking the Miao cross-stitch patterns as an example, representative physical and pictorial materials were collected as research objects and cultural connotations behind them were excavated. Design factors were extracted using split grammar and shape grammar, then evolved into unit patterns. The Mean-shift clustering algorithm was applied to segment the color images and extract the pattern colors, forming the cross-stitch classic color factors. Leveraging the fractal characteristics of brocade patterns, the Julia fractal theory was integrated with brocade pattern design to build a model. This model integrated unit patterns and classic colors to create new patterns that blended fashion and ethnic aspirations. Practical leather accessories design experiments were conducted on Style 3D platform, where innovative patterns were applied to develop contemporary and stylish leather apparel. This study aims to apply Guizhou Miao cross-stitch patterns to modern leather products and propose a set of traditional pattern innovation design paradigms. While respecting and preserving traditional intangible cultural heritage, it actively explores innovation and inheritance, intending to offer methodological references for the development and innovative application of intangible cultural heritage patterns in leather products.

2 Research basis

2.1 Patterns motifs

Miao cross-stitch patterns are characterized by their strong ethnic and regional styles, showcasing exquisite craftsmanship, delicate stitching techniques and rich patterns. They are dominated by abstract geometric shapes, with elements drawn from the daily life and local natural environment of the Miao people. This reflects their reverence for ancestors, love for beautiful things and pursuit of a happy life. Miao cross-stitch pattern elements can be mainly categorized into four types: plant motifs, animal motifs, geometric motifs and other motifs.

Handmade embroidered products are an expression of personal emotions. People imbue them with meaning to convey their desires and present them to the world.¹⁹ The categories of Miao cross-stitch patterns, commonly used elements and meanings are shown in Table I. The Miao people use plants in nature as inspiration for their creations, and common plant motifs include the eight-petal flower, soybean flowers, plum blossoms, peonies and pomegranate flowers. The frequent appearance of animal motifs highlights the Miao people's fondness for animals. Common animal motifs include fishbone, butterfly, bird, frog and ram head patterns. Geometric patterns, comprising various lines and curves forming regular or irregular geometric decorative designs, often feature square, triangular, rhombus, spiral and zigzag shapes. Other motifs include snowflake, coin, silver hat flowers, sun and Miao king seal patterns. The geometrization and exaggeration of cross-stitch patterns enhance their decorative qualities. Despite lacking formal artistic education, local artisans can capture the essence of objects with simplified outlines, which is the charm of folk art.

2.2 Pattern structure

In the composition of Chinese folk art and craftsmanship, emphasis is placed on symmetry and balance. Common composition forms of Miao cross-stitch include clustered flowers, corner flowers and border flowers. Clustered flowers are one of the common forms of cross-stitch pattern composition, with symmetry and circular spatial layout features. Clustered flowers patterns often use fixed frames like "X-shape," "Crisscross-shape" or "Double cross-shape" to serve as the framework for the design (Figure 1). Based on the structural foundation, decorative motifs are added layer by layer

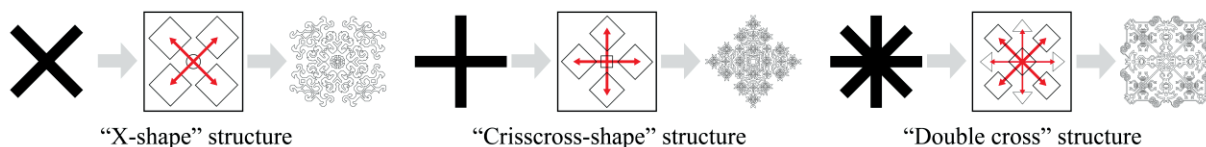


Figure 1. The three common structures of clustered flowers.

around the main body in the margins, with each layer having a different motif. Clustered flowers patterns occupy a relatively large area and are commonly found on the back or around the waist of Miao ethnic clothing. This expansion from the center to the outer layers transforms the pattern from points to surfaces, creating combinations.

Border flowers often appear on the edges of local Miao ethnic clothing, such as the edges of trousers, collars, sleeves and the edges of the waistbands. In cross-stitch, the border flower is mainly composed of bipartite continuity, which is repeated horizontally or vertically to form an infinite continuous pattern. Corner flowers are commonly used at the four corners of the pattern, emphasizing symmetry and balance. Corner flowers are often used in conjunction with clustered flowers to enrich the content of design. In Miao cross-stitch costumes, the clustered flower structure is usually located in the visual center and accounts for a large proportion, while border and corner flowers can complement clustered patterns in their variations. Therefore, this study focuses on exploring the structure of clustered patterns.

2.3 Pattern color

Cross-stitch patterns can be divided into two types based on color: “plain cross-stitch” and “colorful cross-stitch.” In plain cross-stitch, the colors of the threads and the fabric are relatively simple, often using blue or black fabric with white threads. The juxtaposition of these plain colors creates a sense of tranquility and elegance.²⁰ Colorful cross-stitch requires higher craftsmanship from artisans. Artisans need to analyze the overall structure of the pattern first, then consider the use of colors in specific areas to showcase the spatial and layered aspects of the design. The Miao people seek vibrant aesthetics and incorporate their own feelings about colors, making the displayed colors in the patterns more unique. Miao cross-stitch is colorful and contrasting, with a strong local style.

3 Methods

3.1 Elemental derivation methods

3.1.1 Split grammar

Split grammars represent each non-terminal shape with a simple border shape.²¹ Split Grammar breaks down graphic structures into individuals according to specific rules, showing their composition in detail and enabling the deconstruction of complex patterns.²² The Miao cross-stitch pattern system is extensive, rich in hierarchy and

diverse in designs. Split grammar is introduced into cross-stitch pattern design to subdivide and deconstruct the pattern, forming multi-level design elements and facilitating the redesign of pattern elements. This study adopts split grammar to decompose patterns and combines shape grammar to achieve the derivation of pattern elements. An example of split grammar to construct a cross-stitch pattern structure is shown in Figure 2. The initial shape was decomposed to obtain the center pattern X and the largest patterned structural unit of the outer circle F. The decomposition of the pattern unit F was continued and subdivided to obtain the minimal elements U, K. Besides, the decomposition rules were applied to the central pattern unit X, obtaining subdivided elements until they cannot be further decomposed. Multiple smallest elements and the final structure diagram were obtained, the elements obtained from the splitting process could be used in shape grammar for derivation.²³

3.1.2 Shape grammar

Shape grammar was first introduced by George Stiny and James Gips.²⁴ It is a generative system that infers shapes through the application of substitution rules.²¹ By executing corresponding operational rules, it preserves the original form while generating new forms. According to the definition of shape grammar, it can be represented as a function with four components:

$$SG = (S, L, R, I) \quad (1)$$

In the equation: S represents a finite set of shapes, $S = \{S_1, S_2, \dots, S_n\}$ and S^* represents the set of shapes derived from S through inference rules. L is a finite set of labels, $L = \{l_1, l_2, \dots, l_n\}$ and $S \cap L = \emptyset$. R is a finite set of inference rules, $R = \{r_1, r_2, \dots, r_p\}$. The form of an inference rule is $\lambda(S, L) \rightarrow \eta(S, L)$, where $\lambda(S, L)$ is the left-labeled shape for shape inference, $\eta(S, L)$ is the right-labeled shape for shape inference, $\lambda \subset (S \cup L)$, $\eta \subset (S \cup L)$, and η can be an empty set. I is the initial shape, $I = \{i_1, i_2, \dots, i_n\}$ and $I \subset (S \cup L)$.²⁵ The inference rules in shape grammar mainly include move, replace, add, delete, scale, copy, mirror, etc. and the attributes of these rules can be categorized as generative (Figure 3) and derivative (Figure 4).

3.2 Mean-shift color clustering algorithm

Color image segmentation is the basis of quantitative image color analysis.²⁶ Traditional manual color extraction methods are subjective, which is difficult to meet the demand for accurate and quantitative analysis. Mean-shift is a density-based statistical iterative algorithm with fast convergence and a simple process. It can

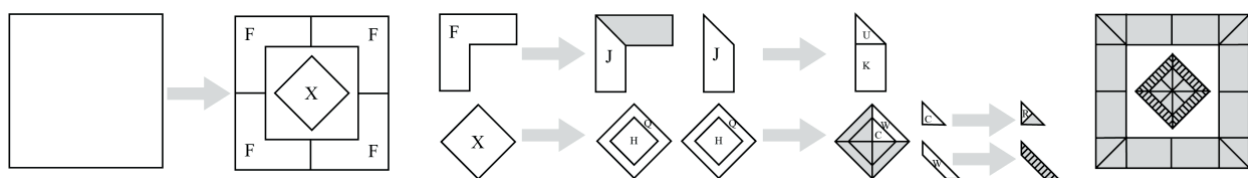


Figure 2. An example of split grammar to construct a cross-stitch pattern structure.

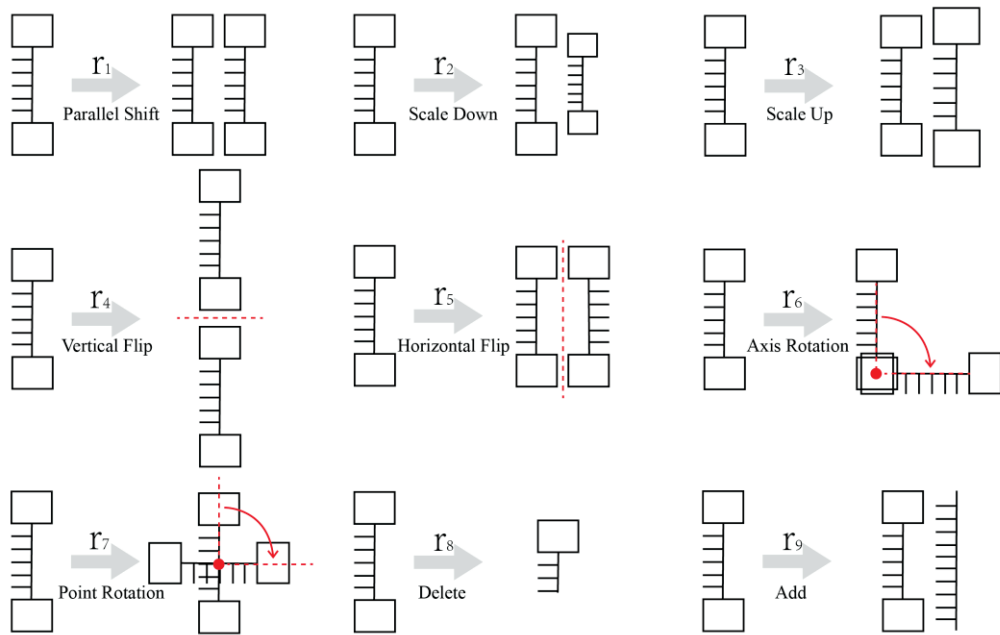


Figure 3. Generative rules.

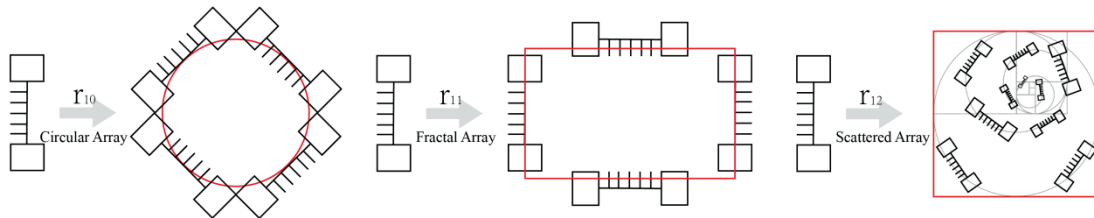


Figure 4. Derivative rules.

retain the main information of an image and is widely used in visual fields such as image computer processing. In this study, we employed the Mean-shift clustering algorithm for image segmentation and primary color extraction. Real-world images of cross-stitch patterns were captured using a digital camera. The Mean-shift clustering algorithm was applied to cluster and analyze the color pixels in the images, followed by extracting color cards for further use.

Assuming a bandwidth h as the drifting window, we calculate the sum of the offsets needed for the center point x_0 to move to the surrounding points x_i within the window. By taking the average of these offsets, we obtain the mean shift $M(x_0)$. Point x_0 is then drifted towards the direction of the average offset to obtain a new center point x_0' . We repeat the above steps until the algorithm converges. The mean shift $M(x_0)$ can be expressed as follows:

$$M(x_0) = \frac{1}{k} \sum_{x_i \in S_h} (x_0 - x_i) \tag{2}$$

In the equation: S_h represents the high-dimensional spherical region centered at x_0 with a radius h . The number of points within the range

of S is k and x_i is the set of points within S_h . By using equation (3), we can obtain the new center point:

$$x_0' = M(x_0) + x_0 \tag{3}$$

Introducing the kernel function in mean shift, denoted as $m(x_0)$, allows us to transform low-dimensional inseparable data into high-dimensional separable data. The specific formula is as follows:

$$M(x_0) = \frac{\sum_{i=1}^k x_i g\left(\left\|\frac{x_0 - x_i}{h}\right\|^2\right)}{\sum_{i=1}^k g\left(\left\|\frac{x_0 - x_i}{h}\right\|^2\right)} - x_0 \tag{4}$$

In the equation, the function g represents the negative derivative of the kernel function. In the aforementioned algorithm, the bandwidth h is a crucial parameter that affects the iterative results of the algorithm. Through experimentation and optimization, the optimal value of the bandwidth that yields the best segmentation effect is determined. Using the aforementioned segmentation algorithm with the optimized bandwidth h , the image is segmented, resulting in pattern segmentation with distinct colors.²⁷

3.3 Fractal pattern design method

“Fractal” and “Fractal Theory” were discovered and proposed by Harvard University professor Mandelbrot. In general, we can regard a fractal as a mathematical set with characteristics of infinite subdivision and self-similarity, which means that it exhibits complex and intricate structures when zoomed in at any scale. Fractals have similar properties, information and functions both at local and global levels.²⁸ Julia fractals were introduced by French mathematician Gaston Julia in 1919, they were extended from the theory of iteration of complex functions. Julia fractal connects various branches from its center, presenting an outward divergent effect and possesses rotational symmetry characteristics. Cross-stitch patterns have the characteristic of repetitive arrangement of unit patterns, the structure of cluster patterns, such as the “X-shaped,” “Crisscross-shape,” and “Double cross-shape” patterns, closely resembles the Julia fractal model. Therefore, incorporating the Julia fractal model in pattern design can efficiently and quickly create cross-stitch patterns that are rich in ethnic charm yet contemporary. Mathematical models are established in the complex domain, after computer processing, complex and futuristic Julia fractal patterns are generated.²⁹ The principle behind the creation of the Julia set graph involves considering an iterative process on the complex plane.³⁰

$$z_{n+1} = z_n^2 + \mu \tag{5}$$

In this equation, $z = x + yi$, z is a complex function, where x and y are variables and i is the imaginary unit. Similarly, $\mu = p + qi$, where μ is a

complex constant and both p and q are constants. By fixing the value of μ and performing iterative calculations, we can create a regular Julia fractal model. By adjusting the exponent, superimposition formula, algorithm, adding representative colors and rendering unit patterns, we can develop cross-stitch patterns that combine ethnic characteristics and a sense of fashion.

3.4 Design paradigm

This study delves into Miao cross-stitch patterns from three perspectives: color, structure and elements, proposes the design paradigm (Figure 5). Firstly, take photos and extract the physical object, then perform color segmentation on the image. Subsequently, we clustered the segmented pattern colors to identify the classic color factors of Miao cross-stitch. Multiple pattern colors were extracted, therefore secondary clustering of multiple sets of colors was required. Moving on to the element extraction process, we initiated by categorizing the themes and analyzing their cultural significance. Afterward, we extracted the pattern outlines and applied split grammar and shape grammar to evolve the patterns, resulting in innovative unit patterns that embody Miao ethnic characteristics. In the structure extraction, we commenced by isolating the pattern structure and assessing its compatibility with fractal models. Then, we established the initial model and made necessary parameter adjustments. The model incorporates classic color factors and innovative unit patterns, ultimately producing suitable fractal cross-stitch patterns. The patterns were rendered clearly and applied to modern leather fashion accessories, completing the design practice.

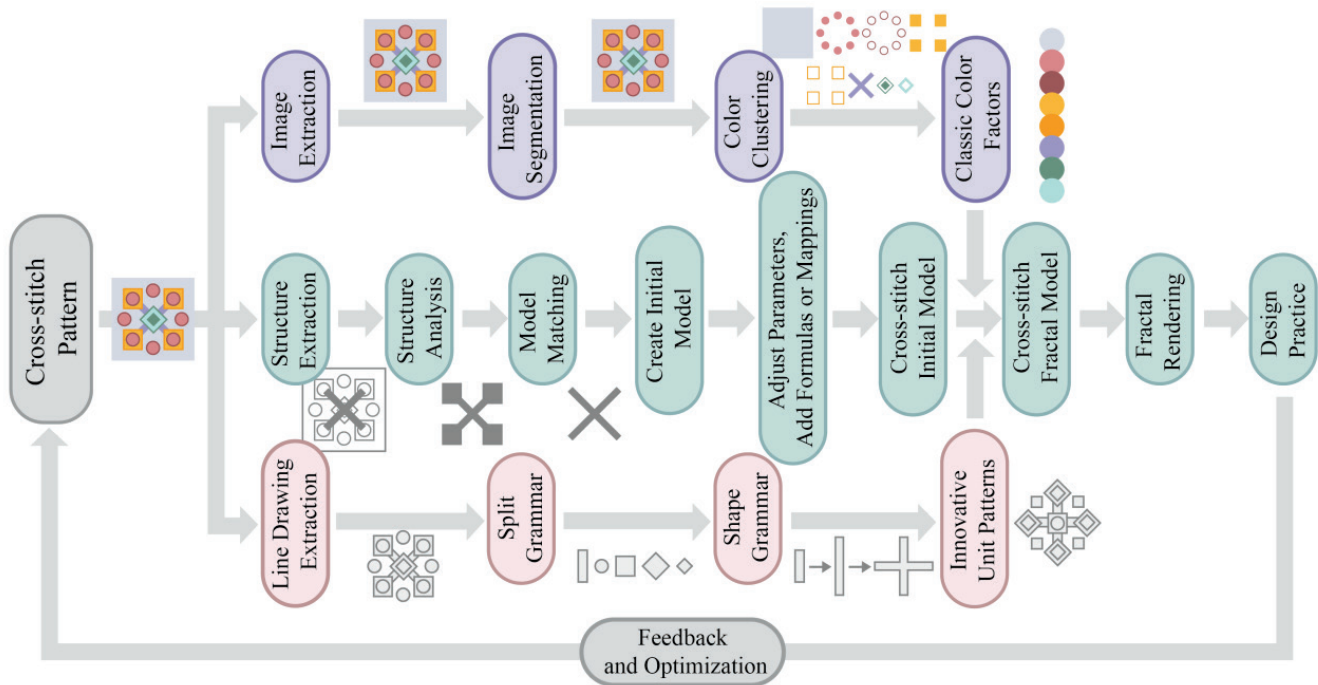


Figure 5. Design paradigm.

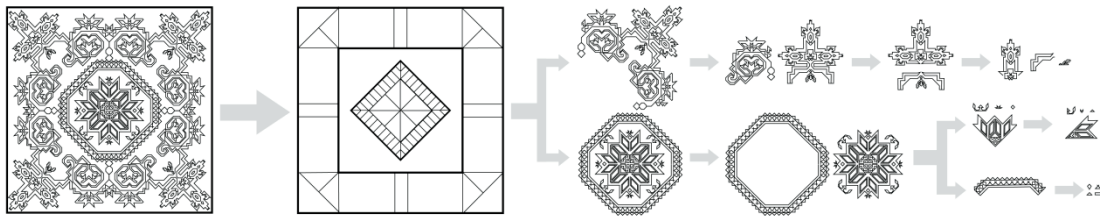


Figure 6. The structure of the eight-petal pomegranate flower pattern under the split grammar rule.

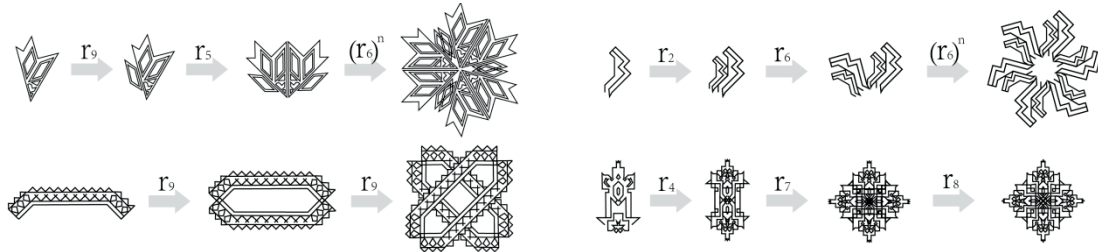


Figure 7. The innovative pattern units.

4 Application

4.1 Derivation of Miao cross-stitch element

Researchers extracted black and white outlines of cross-stitch patterns and applied the concept of split grammar for decomposition. We combined shape grammar to infer and derive decomposed pattern elements, resulting in new patterns with prototype characteristics. These new patterns can serve as novel basic pattern units. As an example, for structural analysis of cross-stitch patterns, the study focused on the eight-petal pomegranate flower pattern. This pattern was selected as the initial shape and used for structural analysis using splitting grammar (Figure 6).

By executing split grammar rules, the pattern was decomposed into a central eight-petal flower and an outer ring pomegranate flower. The outer circle pattern was repeatedly decomposed and then further analyzed until the pattern units could no longer be decomposed, obtaining multiple cross-stitch pattern elements. These split elements were subjected to inference and derivation using shape grammar, resulting in innovative unit patterns (Figure 7). Further utilizing shape grammar for combination and arrangement of the innovative unit patterns, produced more complete and innovative Miao cross-stitch patterns (Figure 8). The researchers completed several representative innovative pattern units, which could be applied and transformed as classic elements of Miao cross-stitch in subsequent fractal designs.

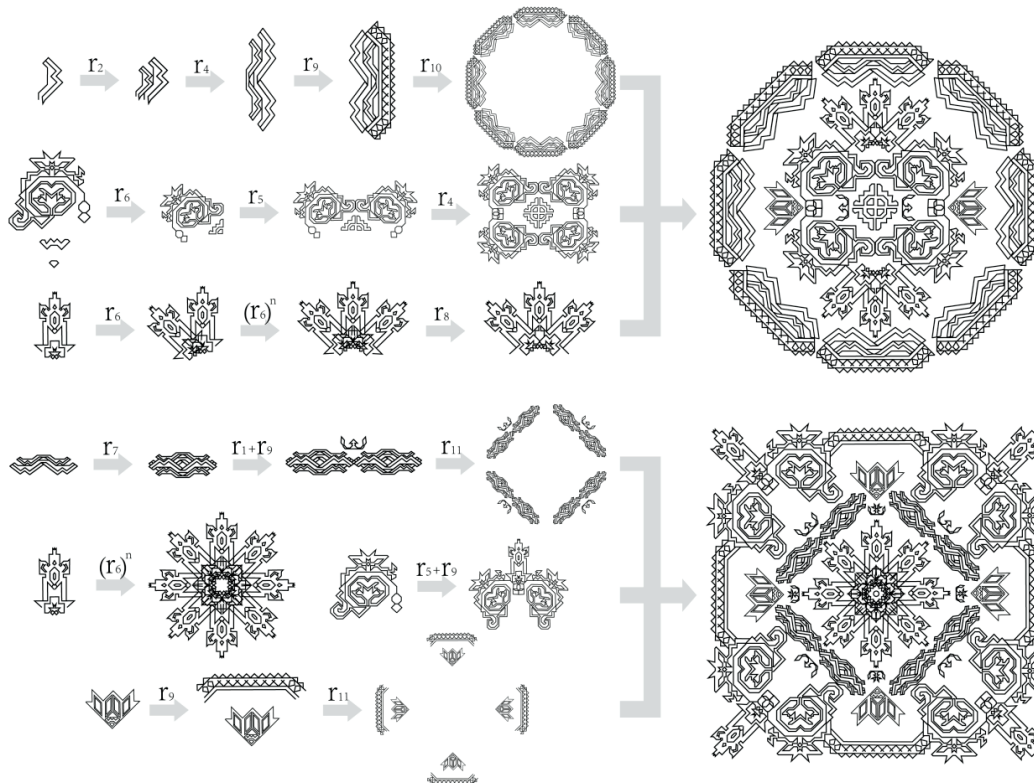


Figure 8. The combined effect of the innovative pattern units.

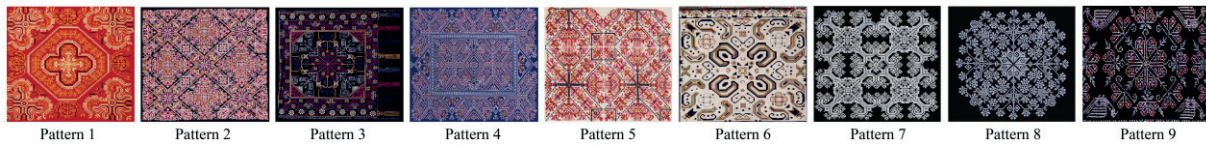


Figure 9. Nine sets of Miao cross-stitch patterns (the colored cross-stitch patterns are named Pattern 1 to Pattern 6 and the plain cross-stitch patterns are named Pattern 7 to Pattern 9).

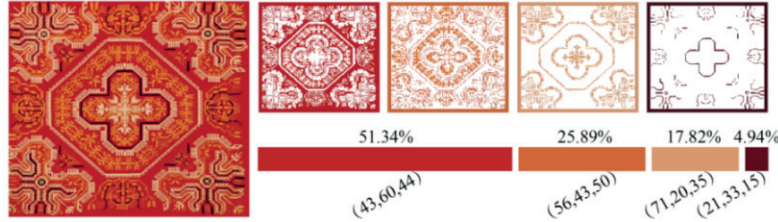


Figure 10. The color segmentation result of Pattern 1.

4.2 Color design of Miao cross-stitch

Color, as a medium of perception and a visual language, can intuitively reflect the character traits of different ethnic groups.³¹ The combination of colors determines the visual effect presented in the local Miao cross-stitch. Researchers focused on two categories (plain cross-stitch and colored cross-stitch) to collect patterns. From the large collection of cross-stitch images, three sets of plain cross-stitch and six sets of colored cross-stitch were randomly selected (Figure 9). Taking colored cross-stitch pattern 1 as an example, the color segmentation of the image was carried out using the equations 2 to 4 (Figure 10).

















Color segmentation and clustering extraction were applied to the nine sets of patterns using the same method. The extracted nine sets of colors were manually clustered again and the main colors and secondary colors were divided based on their proportion, serving as the classic color factors for Miao cross-stitch (Figure 11).

Four main colors and eight secondary colors were selected for the colored cross-stitch patterns, while two main colors and two secondary colors were selected for the plain cross-stitch patterns, as shown in Table II, with their corresponding RGB values indicated.



Figure 11. The Process of color extraction and selection.

Table II
Classic Pattern Colors and their RGB Values

Category	Main Color (RGB Values)		Secondary Color (RGB Values)	
colored cross-stitch		black (23, 21, 28)		light orange (216, 184, 97)
		pink (200, 164, 165)		purple (155, 72, 103)
		red (195, 36, 31)		blue (27, 43, 87)
		white (249, 246, 243)		orange (199, 97, 51)
plain cross-stitch		black (23, 21, 28)		dark red (91, 22, 28)
		grey (201, 201, 202)		green (47, 95, 70)
				khaki (178, 138, 51)
				beige (219, 205, 185)
			purplish grey (135, 139, 154)	
			dark red (91, 22, 28)	

The selected colors will be further applied in fractal design as classic color factors for Miao cross-stitch patterns.

4.3 Miao cross-stitch pattern design

According to the layout of “X-shaped,” “Crisscross-shape” and “Double cross-shape” structures in cross-stitch pattern, we modified the Symmetry Order index in the primary Julia fractal model in Ultra Fractal software version 6.04. We selected the symmetry order index of 4 for the primary model in the “X-shaped” structure design and adjusted the Rotation Angle to 45 degrees. By adding Inverse mapping, Newton formula and Aspect Ratio mapping, we

obtained three different forms and effects of new models (Figure 12). On this basis, we can further superimpose new mappings or formulas to pursue more intricate and exquisite pattern effects. After completing the modification of the model to its color design, in the gradient adjustment window of the model to add the cross-stitch representative color factor, pattern elements obtained from the screening in the previous section, to obtain a complete fractal pattern.

When the symmetry order index was 4 and 8, the rotation angle was set to 0, we can also obtain the “Crisscross-shape” (Figure 13)

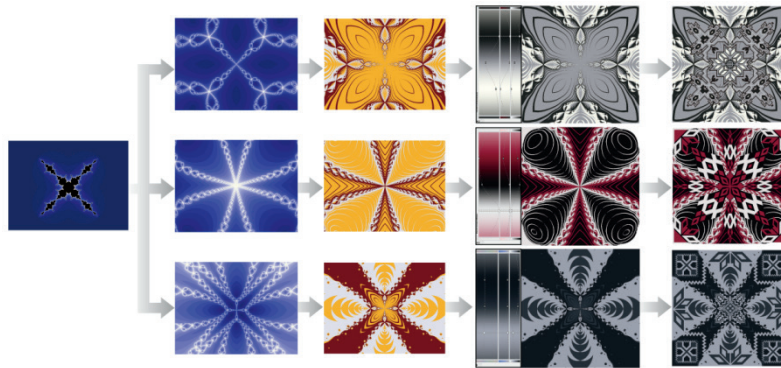


Figure 12. “X-shaped” structured fractal cross-stitch pattern

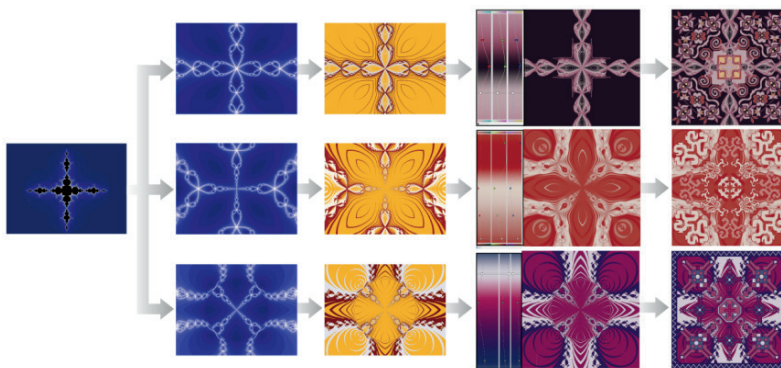


Figure 13. “Crisscross-shape” structured fractal cross-stitch pattern

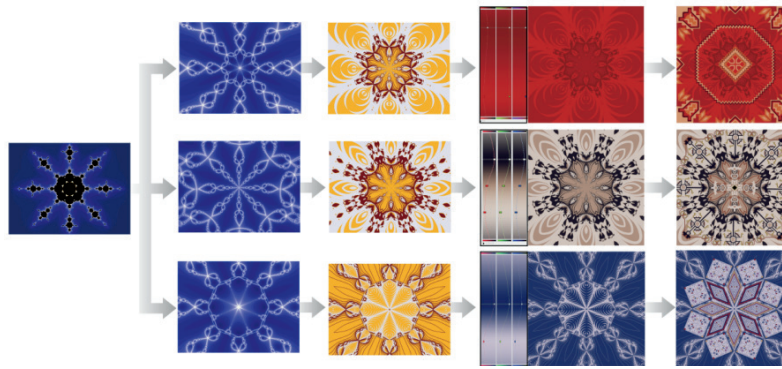


Figure 14. “Double cross-shape” structured fractal cross-stitch pattern

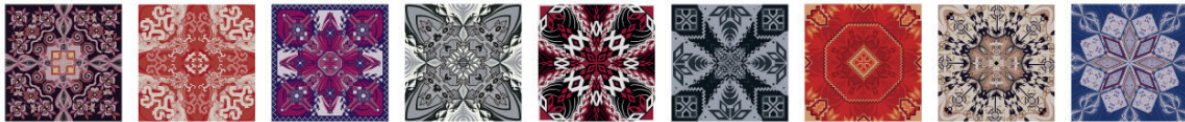


Figure 15. Nine sets of Miao ethnic fractal cross-stitch patterns

and “Double cross-shape” (Figure 14) structured fractal patterns through the above steps. Three structures generated nine sets of Miao ethnic fractal cross-stitch patterns (Figure 15). It can be observed that different index settings lead to vastly different fractal patterns and the variations in colors also result in distinct visual experiences.

4.4 The Application of cross-stitch Patterns in Leather Apparel

Clothing virtual display technology can simulate a more realistic wearing effect in advance. In recent years, 3D design software has been widely used in the fashion industry. 3D virtual clothing has many advantages, such as rapid adjustment of plates, reduction of resource waste, virtual try-on and show, which can help designers

efficiently complete complete fashion designs. Currently, some mature clothing 3D software includes Optitex 3D from the United States, Lecra from France, Agms Industry 3D from Japan, V-Stitcher from Israel, Clo 3D from South Korea and Style 3D from China. To verify the feasibility of the fractal cross-stitch pattern design model, we chose Style 3D software for the design and 3D presentation of leather apparel and accessories.

Design practice was carried out on the Style 3D platform on a random set of 5 cross-stitch fractal patterns obtained (Figure 16). The front view of the leather apparel and leather accessory sets completed using the 5 sets of fractal cross-stitch patterns (Figure 17). Each set of patterns was applied to the design of a complete

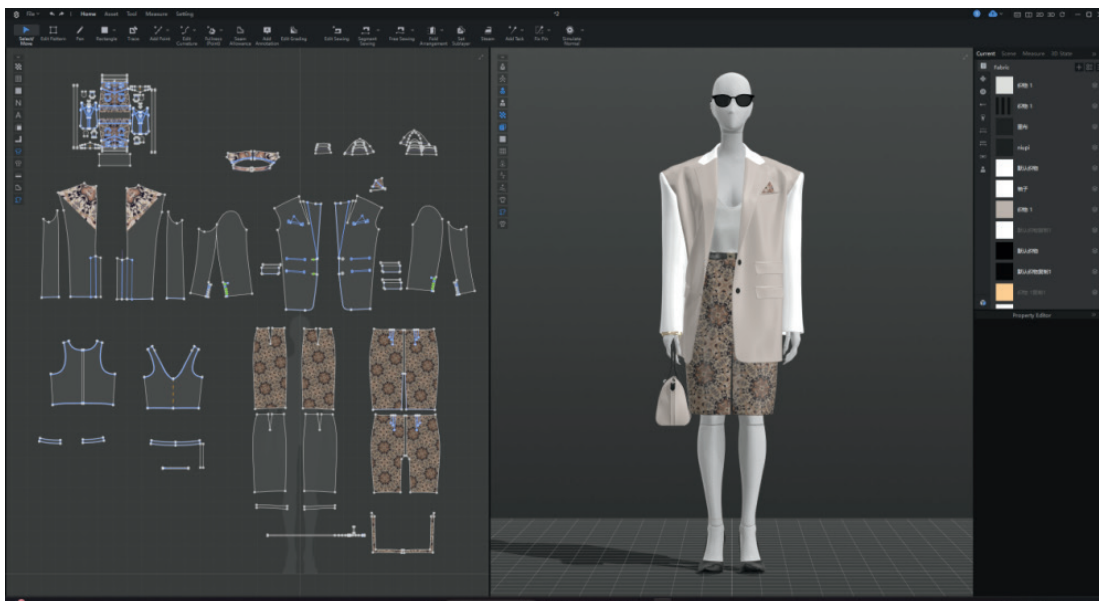


Figure 16. Style 3D modelling interface.



Figure 17. The front view of the leather apparel and accessory sets completed using the 5 sets of fractal cross-stitch patterns.

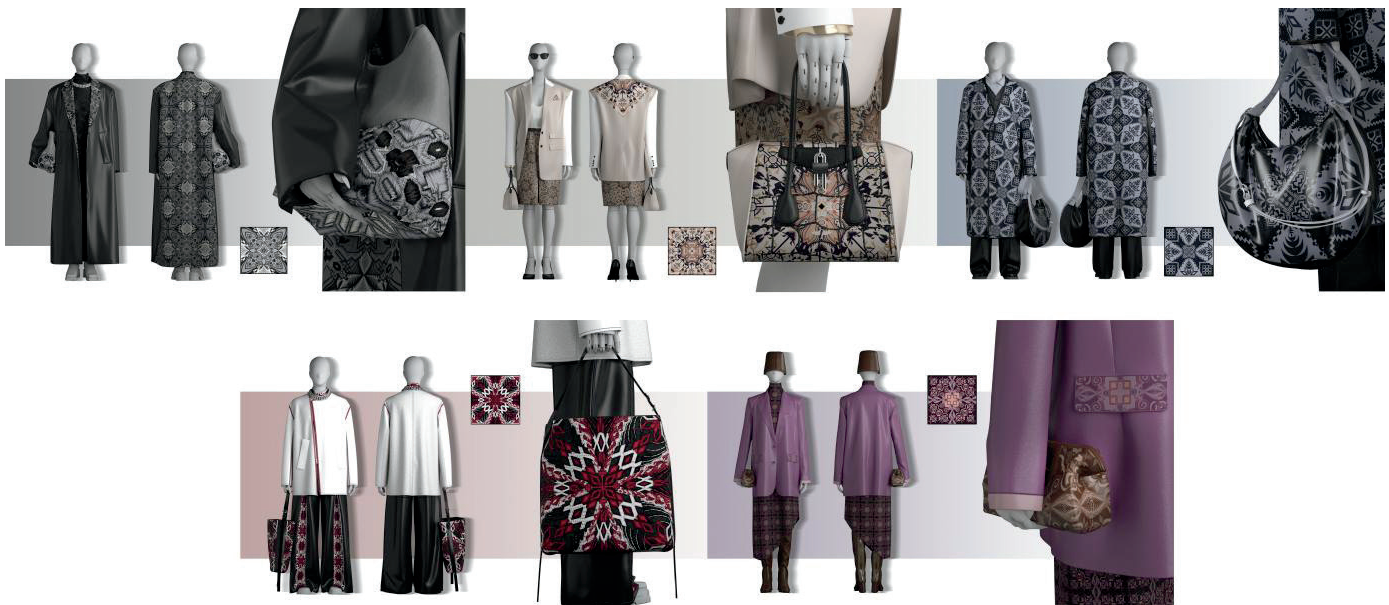


Figure 18. The overall design of the clothing's front and back, the display of the leather bag's detailed craftsmanship and the corresponding pattern

series of apparel and accessories. Apparel and accessory patterns were drawn using clothing CAD software and saved in “.dxf” file format before importing them into Style 3D software version V6.0.831 for clothing modeling. After importing the patterns into the 3D software, clothing and leather accessory pieces were placed and adjusted multiple times to ensure natural fall and stitching of the pieces in the simulation state. Any parts with unsatisfactory fit were promptly adjusted to maintain structural integrity. When presenting product effects in the field of leather product design and fashion design, realistic textures are usually required to be visualized.³² Adding or adjusting the material and physical properties of the fabric can reproduce the realistic texture of leather

materials. The designed fractal cross-stitch patterns were added to the samples to achieve the final presentation effect.

The overall front and back design of the leather garment, the details of the leather bag craftsmanship and the corresponding pattern effects are shown in combination (Figure 18). Researchers opted for modern and sleek straight-line silhouettes, presenting a minimalist and elegant style. For the color scheme, we chose to match the patterns with colors from the same color palette, creating a comfortable and classic visual experience. In craftsmanship, cross-stitch and printing techniques were selected to showcase rich three-dimensional effects and colorful decorative effects.

5 Conclusions

The protection and inheritance of intangible cultural heritage are crucial for maintaining cultural diversity and ensuring cultural sustainability. Miao cross-stitch, as an important intangible cultural heritage in China, showcases high cultural identity and artistic value. This study analyzed the thematic elements and representative motifs of Miao cross-stitch, as well as the color characteristics and pattern structure rules. By integrating split grammar, shape grammar and pattern evolution, precise pattern colors are extracted using clustering algorithms. Based on Julia fractal model and computer algorithms, a traditional pattern innovation design paradigm was proposed. Furthermore, the researchers have completed a series of five sets of leather apparel designs based on the generated innovative patterns. The results demonstrated that combining intangible cultural heritage cross-stitch craftsmanship with leather product design can not only preserve Guizhou's folk culture but also better meet consumers' personalized demands. The aim of this study was to support the dynamic inheritance of local excellent intangible cultural heritage, promote the transformation of economic benefits in leather product design, provide theoretical reference and methodological guidance for innovative design with intangible cultural heritage in leather products.

Acknowledgment

This work was financially supported by the Humanities and Social Science Project of Ministry of Education, China (21YJC850013).

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