The Modern Transformation and Design Research of Fuyang Paper Cutting under The Perspective of Shape Grammar

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ABSTRACT

This paper investigates the modern transformation and application of Fuyang paper-cutting patterns to protect and promote the inheritance and development of Fuyang paper-cutting while also exploring effective ways to preserve it. This study employs qualitative analysis methods, including literature review and case studies. It combines the Shape Grammar (SG) theoretical model with computer-aided design technology to conduct an in-depth exploration and analysis of Fuyang paper-cutting patterns. As a result, related derivative pattern elements were generated and applied in relevant product designs. The research findings indicate that the derivative patterns of Fuyang paper-cutting generated using the "SG" theory model can be successfully applied in modern product design. It also effectively broadens the channels for disseminating Fuyang paper-cutting as intangible cultural heritage, providing valuable references and insights for the living inheritance and sustainable development of intangible cultural heritage.

Keywords: *Fuyang paper cutting, Shape grammar, Pattern design, Cultural and creative products*

INTRODUCTION

As an integral part of China's intangible cultural heritage, Fuyang paper-cutting not only carries rich historical and cultural information but also showcases distinct local characteristics. Its unique art form and profound cultural heritage vividly reflect the wisdom and aesthetic concepts of the Chinese nation. However, in the process of globalization and modernization, Fuyang paper-cutting faces unprecedented challenges, including difficulties in skill transmission, market contraction, and a gradual disconnection from modern lifestyles. In the face of these challenges, how to achieve innovation and modern

transformation while preserving its traditional essence to adapt to new aesthetic trends and market demands has become a core issue that needs urgent resolution. As a theoretical framework, Shape Grammar (SG) provides a systematic set of analytical and shape-generating rules, especially suitable for the field of visual arts and design. Using this method, we can systematically deconstruct Fuyang paper-cutting patterns and provide scientific support for transforming traditional art into modern design.

LITERATURE REVIEW

The Transmission and Protection of Fuyang Paper-cutting

Gao (2022) addressed the series of developmental challenges faced by Fuyang paper-cutting, such as outdated communication methods, and proposed corresponding solutions. By expanding communication channels through social media and online platforms, the aim was to promote the art's heritage and development in contemporary times. Zhang (2022), from the perspective of cultural heritage digitization, conducted an in-depth study on the preservation and development pathways of Fuyang paper-cutting, exploring how digital technologies can be utilized for its effective protection and widespread dissemination.

On the other hand, Jiang (2014), from the perspective of the development of artistic derivatives, explored the strategic development pathways for Fuyang paper-cutting in the modern commercial environment. The author proposed achieving the commercialization and modernization of Fuyang paper-cutting through product innovation, brand building, and cross-industry collaboration. Meanwhile, Li (2022) argued that the inheritance and development of Fuyang paper-cutting require the establishment of a core area for intangible cultural heritage and promotion through diverse forces. It also includes improvement of the intangible cultural heritage inheritance mechanism, assimilation of traditional culture, and enhancement of the competitiveness of local products.

These studies collectively emphasize the multifaceted approaches used to protect, understand, and utilize Fuyang paper-cutting in contemporary contexts, highlighting its cultural significance and potential for economic revitalization. They reveal how strategies such as establishing a core area for intangible cultural heritage, utilizing digital technologies and modern communication methods, and promoting product innovation and brand development can effectively preserve and promote this traditional art form.

The Artistic Characteristics and Aesthetic Tendencies of Fuyang Paper-cutting

Zhu (2021) explored the evolution of the aesthetic tendencies of Fuyang paper-cutting from three aspects: the loss of folk culture, the decline of creative practitioners, and the impact of market operations. The author's research provided a comprehensive overview of the challenges faced by Fuyang paper-cutting in contemporary society and suggested potential solutions to address these issues. At the same time, Cao (2022) explored the visual thinking behind Fuyang paper-cutting art and drew on its cultural resources to achieve the localized adaptation of contemporary art creation methods, emphasizing traditional cultural symbols. In addition, Yu (2016) highlighted that Fuyang paper-cutting possesses natural and romantic imagery with stylistic characteristics, borrowing from the expressive language of painting. It is filled with simplicity and spontaneity, as well as a dynamic and ethereal atmosphere.

The Modern Design Transformation and Application of Fuyang Paper-cutting

Alternatively, Yan (2022) explored how the visual cultural elements of Fuyang paper-cutting can be integrated into the design of cultural and creative products, thereby enriching their aesthetic appeal and cultural depth.

Meanwhile, Yu (2024) delved into how to distill and analyze the visual elements of Fuyang paper-cutting and integrate them into the packaging design of cultural and creative products. This approach opens up new avenues for the inheritance and development of intangible cultural heritage, making it more accessible and appealing to contemporary audiences. Furthermore, Li (2018) proposed combining Fuyang paper-cutting culture, a significant visual identity of the city, with modern anime art. This fusion revitalizes the traditional art form and promotes the development of Fuyang paper-cutting culture by introducing it to younger audiences and expanding its reach through popular media.

These studies demonstrate the innovative ways in which Fuyang paper-cutting can be adapted and utilized in various modern design contexts, contributing to its preservation while simultaneously ensuring its relevance and vitality in today's society. The research related to Fuyang paper-cutting is a comprehensive topic involving multiple fields of cultural inheritance and protection, artistic characterization, and modern transformation and application research. Notably, the current research has made some progress. Yet, there is still much room for development in terms of combining modern technological means for digital protection, cultural living inheritance, and intelligent design. In the future, the visual pattern elements of Fuyang paper-cutting should utilize modern advanced technology to assist its cultural inheritance and development and be combined with commerce to ensure its vitality for sustainable development.

RESEARCH METHODOLOGY

To analyze the modern transformation and design research of Fuyang paper-cutting, qualitative research methods were employed, including literature analysis and case studies.

Literature Analysis

By systematically searching relevant books, academic journals, and online resources and carefully selecting and organizing the materials, we have selected Fuyang paper-cutting works exhibiting significant artistic characteristics and profound cultural connotations. These selected works are renowned for their simple yet powerful designs, graceful lines, and distinctive themes, each deeply embedded with rich folk meanings. Depending on the subject matter, these paper-cutting works can be further categorized into major groups, such as figures, animals, plants, and geometric shapes.

Case Study

Through an in-depth literature analysis, six classic Fuyang paper-cutting works were carefully selected, and their morphological elements were extracted. Subsequently, SG theory was applied to these six extracted elements, with morphological derivations conducted using various techniques such as replication, scaling, rotation, mirroring, and the use of Bézier curves. The aim was to generate derivative patterns that meet commercial design needs. Ultimately, these derivative patterns were applied to the

design of cultural and creative products, with the case presented in this paper being their application on a silk scarf. The actual display effect of the scarf validated the applicability and innovation of the "SG" generation system in adapting traditional Fuyang paper-cutting patterns to modern design. Accordingly, by applying SG theory to the study and demonstration of this specific case, we provided a clear pathway for the practical application of traditional art in modern design. This particularly opens up new ideas for the living inheritance and contemporary development of intangible cultural heritage. This research offers valuable insights and references for designers, artists, and cultural heritage practitioners, contributing to the sustainable development of traditional intangible cultural heritage.
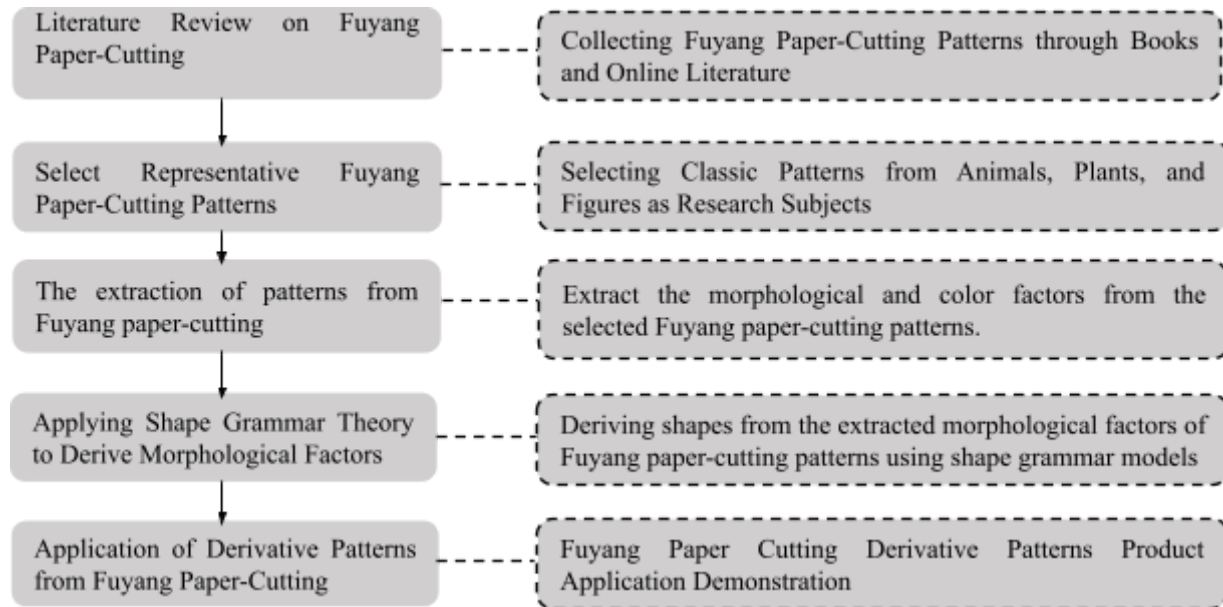
Figure 1. Design Framework Flowchart
(Source: Li, 2024)

FINDINGS

Types and Characteristics of Fuyang Paper-cutting Patterns

Fuyang paper-cutting is a traditional folk art from Fuyang, Anhui Province, China, with a history that dates back to the North and South Dynasties. This art form cleverly integrates the characteristics of both northern and southern paper-cutting, reflecting the delicate elegance of southern paper-cutting and the robust simplicity of northern paper-cutting. Fuyang paper-cutting is widely used, especially during festive celebrations when people create window flowers, lanterns, and joyful decorations from red paper. These works often carry auspicious and favorable wishes. Additionally, they are used as basic patterns for embroidery on children's clothing, with common themes including plants, animals, and human figures. Notably, Fuyang paper-cutting primarily uses paper as the material and employs techniques such as cutting, carving, and dyeing to create rich contrasting effects between reality and illusion through skeletal images (Hu, 2007).

As a crucial intangible cultural heritage, Fuyang paper-cutting boasts a long history, with its unique pattern designs reflecting local customs and incorporating historical legends. By exploring the modern

transformation and application design of Fuyang paper-cutting patterns, we can better protect and inherit this precious cultural heritage while infusing it with new vitality. In terms of composition, Fuyang paper-cutting focuses on balance and symmetry while also incorporating variation, resulting in a layout that is both rigorous and dynamic. In particular, the pattern design emphasizes continuity and repetition, making it ideal for deriving regular pattern combinations. These characteristics make Fuyang paper-cutting a folk art form with significant artistic value and practical utility.

Formal Analysis of Fuyang Paper-cutting

The patterns of Fuyang paper-cutting are diverse and rich, mainly encompassing elements from folklore, mythological stories, and festival celebrations. Auspicious symbols such as blessings, longevity, and happiness are widely used. At the same time, symbolic elements like dragons, phoenixes, lotuses, and fish are skillfully integrated into the paper-cutting, expressing people's aspirations and wishes for a good life. Fuyang paper-cutting excels at using wavy lines with varying degrees of curvature, which imbues the works with a sense of dynamism and beauty, creating visual tension and rhythm (Wu, 2008).

From a technical perspective, Fuyang paper-cutting combines various techniques such as cutting, carving, and tearing. The skillful combination of yin and yang cutting, along with the use of thick and thin lines, greatly enhances the artistic expression of the works. In terms of color selection, monochrome, especially red, is the most common color, symbolizing auspiciousness and celebration. Additionally, various color treatment methods, such as dyeing, collage, and overlay, make the works colorful and vibrant. Meanwhile, the composition strives for balance and harmony with smooth lines, allowing even the most complex patterns to be presented in an orderly and simple manner. Each pattern carries a specific symbolic meaning; for example, fish symbolizes abundance year after year, and peonies represent wealth and prosperity. These elements deeply reflect the significance of auspicious symbols in traditional Chinese culture. Note that Fuyang paper-cutting is a form of decorative art and an essential carrier of folk culture. The transmission of patterns highlights the philosophy of life of the people of Fuyang and reflects their aesthetic pursuits and spiritual world.

Origins and Development of the Theory of Shaped Grammar

SG is a design and analysis method based on the theory of "symbolic language" (formal language) proposed by American design and computation theorists George Stiny and James Gips (Qiing, 2019). A design and analysis method based on the theory of "symbolic language" (formal language) is mainly based on "shape" operations. SG can be expressed as SG = (S, L, R, I) where S is the set of shapes, L is the set of labels, R is the set of inference rules, and I is the set of initial shapes (Li, 2019). In particular, SG inference rules can be categorized into generative rules and modification line rules: generative rules include additions, deletions, and substitutions; modification line rules include scaling, mirroring, copying, rotating, miscutting, and Bézier curves (Feng, 2022). Meanwhile, additions and deletions refer to the addition or deletion of graphical form curves; substitutions refer to the replacement of the original graphical form curves; scaling refers to the reduction or method of the graphical external form curves. Mirroring refers to the symmetrical inversion of the graphical form along the X- or Y-axis. At the same time, copying is used to create a copy of the graphical form, while rotations refer to the rotation of the graphical form by a certain angle with a certain point as the center of the circle with a certain degree of rotation and change. Bézier curves refer to the alteration of some of the graphical nodes to make minor adjustments to achieve a subtle shape change.

Selection and Confirmation of Research Objects

Through a detailed analysis of both online and offline literature and after multiple rounds of selection, we carefully filtered a set of representative Fuyang paper-cutting samples. These samples not only highlight the traditional craftsmanship and unique aesthetic requirements of Fuyang paper-cutting but also deeply reflect the rich cultural heritage and national spirit of the region. Representing the cultural essence of Fuyang, these paper-cutting works, with their simple yet powerful designs and elegant flowing lines, convey folk stories and life wisdom passed down through generations. Next, these samples will be reinterpreted under the theoretical model of SG, utilizing SG derivation methods to conduct an in-depth analysis and innovative interpretation of their morphological elements. Using computer design software technology, these Fuyang paper-cutting patterns have been deeply explored and digitally sampled. Through image recognition and design processing, the representative pattern elements of the paper-cutting patterns have been extracted, laying a data foundation for subsequent modern transformation design.

Design Factor Extraction

The patterns of Fuyang paper-cutting come from a wide range of sources, with diverse forms and rich content. Throughout its development, various paper-cutting themes have emerged based on different uses, locations, times, and spatial distributions, primarily including auspicious, plant, and animal motifs (Lin, 2017). Using graphic design software (Illustrator), we employed the "Pen Tool" to outline and analyze the morphology of Fuyang paper-cutting patterns. Through digital processing techniques, six typical patterns were selected from Fuyang paper-cuttings as research subjects. Consequently, by further extracting these patterns and applying SG theory, combined with design software, six of the most representative morphological factors were ultimately derived, namely H1, H2, H3, H4, H5, and H6 (Table 1). In addition, for color extraction, we also used the color picker tool in Illustrator software to precisely extract the colors of six representatives Fuyang paper-cutting samples, numbered S01 to S06. Subsequently, the color values of each sample are represented in the CMYK color mode (Table 2). This process laid the foundation for further color analysis and design research.

Table 1. Extraction of Morphological Factors of Patterns

Pattern 1	Pattern 2	Pattern 3	Pattern 4	Pattern5	Pattern 6
Figure1	Figure2	Figure3	Figure4	Figure5	Figure6

Form factor H1	Form factor H2	Form factor H3	Form factor H4	Form factor H5	Form factor H6

Table 2. Color Factor Extraction Library for Fuyang Paper Cutting Patterns
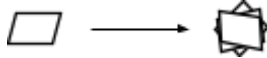
S01	S02	S03	S04	S05	S06
Color Extraction1	Color Extraction 2	Color Extraction 3	Color Extraction 4	Color Extraction5	Color Extraction 6
C: 100 M: 87 Y: 29 K: 0	C: 43 M: 95 Y: 23 K: 0	C: 44 M: 100 Y: 78 K: 9	C: 76 M: 20 Y: 49 K: 0	C: 74 M: 100 Y: 43 K: 7	C: 22 M: 99 Y: 99 K: 0

Table 3. Rule derivation process

R1（Replication）	**R2**（Resizing）	**R3**（Mirroring）
R4（Permutation）	**R5**（Center Rotation）	**R6**（Endpoint rotation）
R7（increase）	**R8**（deletion）	**R9**（Bessel curve）

Fuyang Paper-cutting Pattern Deduction Design

To better understand how the basic form factors of Fuyang paper-cutting patterns can be applied in design, we employed SG for design deduction, which includes two forms: generative deduction and derivative deduction (Table 3). The following is an example of the specific design process.

Paradigm 1: Select form factor H1 (see Table 1) as the research object and use SG for design deduction. The steps are as follows: First, import the H1 graphic into graphics processing software (such as Adobe Illustrator). By applying the R8 (delete) command from Figure 1a to remove unnecessary parts, we obtain Figure 1b. Next, the R4 (replacement) operation is applied to Figure 1b, rotating it to adjust its direction, resulting in Figure 1c. Continue using the R9 (Bézier curve) command to optimize the edges of Figure 1c, making the lines smoother, and thereby obtain Figure 1d. Consequently, apply the R1 (copy) and R3 (vertical mirror) commands to Figure 1d to generate Figure 1e. Based on Figure 1e, continue using the R5 (center rotation), R1 (copy), and R3 (vertical mirror) commands to obtain Figure 1f. Finally, by executing the R1 (copy) and R3 (vertical mirror) commands once more, the base graphic for the cultural and creative product that meets the usage requirements, Figure 1g, is generated (Figure 2).

Figure 2. Fuyang paper-cutting pattern deduction 1
(Source: Li, 2024)

Paradigm 2: The morphology factor H4 of (Table 1) is selected as the research object; the deduction design of SG is performed. First of all, the H4 graph is imported into the computer software, Figure a is deleted (R8) command to get Figure 2b, Figure b and then Bessel curve (R9) to make it smooth to obtain Figure C, Figure 2C is deleted (R8) to get Figure 2d, Figure d and at the same time replacement (R4) to get Figure 2e, and then copy (R1), mirror (R3) to get in line with the use of the corresponding creative arts products. The base for Figure 2f is obtained by performing copy (R1) and mirror (R3) (Figure 3).
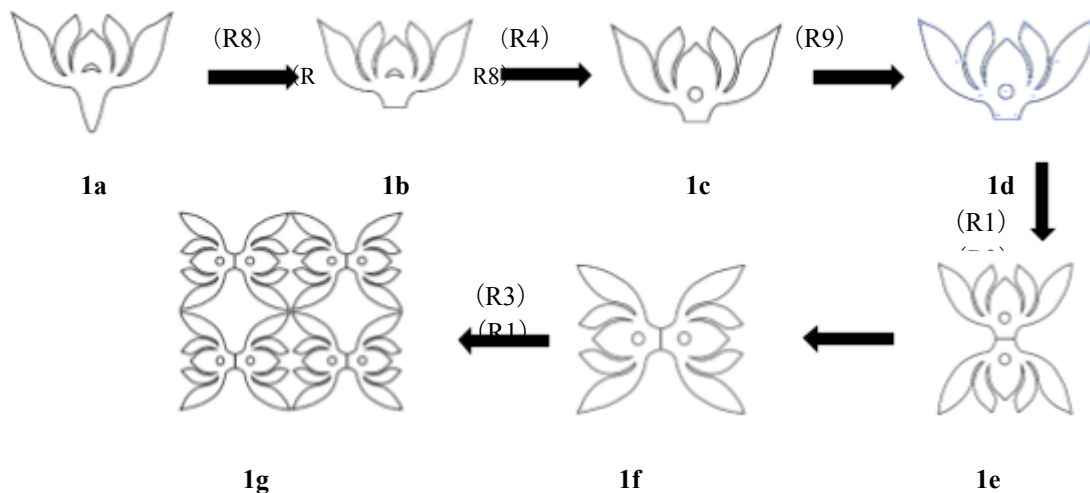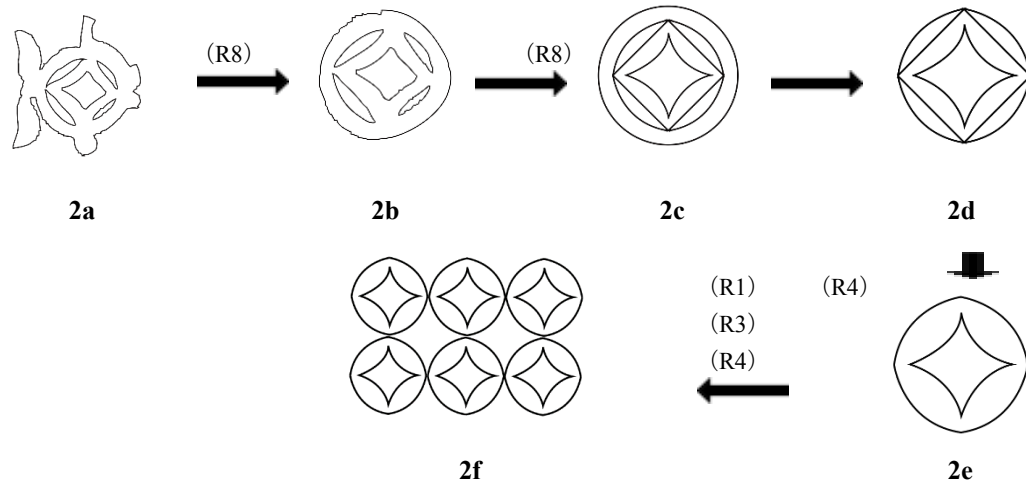
Figure 3. Fuyang paper-cutting pattern deductionc2
(Source: Li, 2024)

Paradigm 3: The morphology factor H6 (Figure 1) is selected as the research object; the deduction design of SG is carried out. First of all, the H6 graphic is imported into the computer software. The deletion (R8) command is executed in Figure 3a to get Figure 3b. Subsequently, the replacement (R4) command is executed in Figure 3b to get Figure 3c. Then, the Bessel curve (R9) command is executed in Figure 3c to get the smoother Figure 3d. The operation of copying (R1) and mirroring (R3) in Figure 3d is executed in Figure 3e at the same time to get Figure 3f, and the copying (R1) and mirroring (R3) operations are continued to generate the base for Figure 3f that conforms to the use of the corresponding cultural and creative products. (Figure 4).

Figure 4. Fuyang paper-cutting pattern deduction3
(Source: Li, 2024)

Paradigm 4: The (Table 1) morphology factor H5 is selected as the object of study; the derivation design of the SG is carried out. First of all, the H5 graphic is imported into the computer, and the deletion (R8) is executed in Figure 4a to obtain Figure 4b. Then, the mirroring (R3) and Bessel curve (R9) commands are continued to be implemented to obtain4c The duplication (R1) and rotation (R5)

commands are performed in Figure c to obtain Figure 4d, and the implementation of the Bénédicte increase (R7) command is performed in Figure 4d to obtain Figure 4e. Figure 4e is then respectively duplicated (R1) and mirrored (R3) to generate the base for Figure 4f that conforms to the use of the corresponding cultural and creative products (Figure 5).

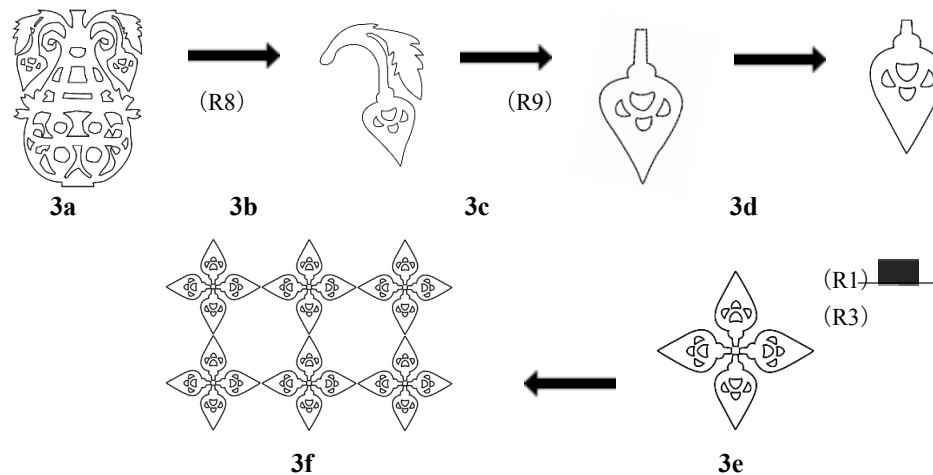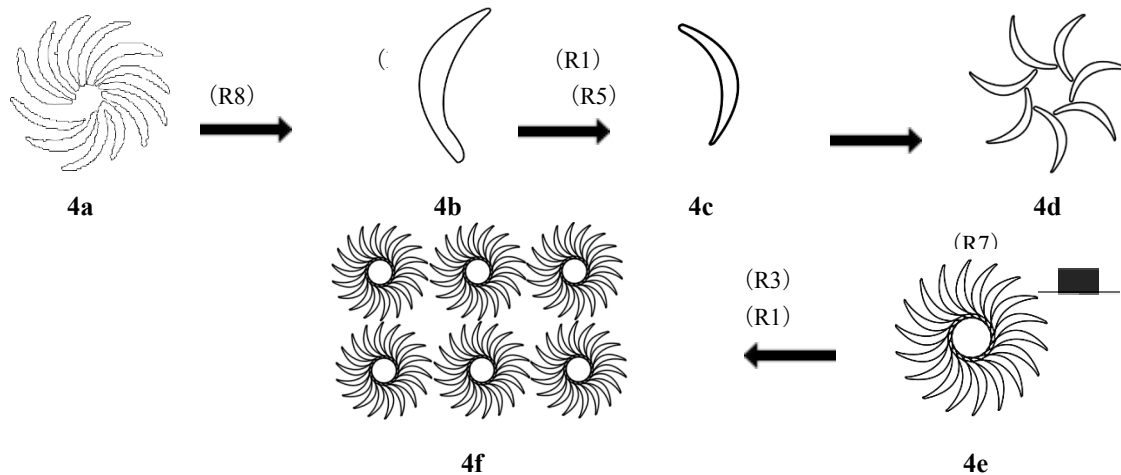**Figure 5. Fuyang paper-cutting pattern deduction4**
(Source: Li, 2024)

Fuyang Paper-cutting Pattern Cultural and Creative Product Design Application

Fuyang paper-cutting, as an integral part of Chinese folk art, is famous for its unique artistic style and deep cultural heritage. Its patterns are rich and varied, containing elements such as plants and animals with auspicious symbols, myths and legends, and historical stories, to name a few. With bright colors and smooth lines, it is very suitable for use in the design of cultural and creative products. It not only inherits the traditional culture but also meets the needs of modern aesthetics and life.

Continuity of Cultural Genes

The application of Fuyang paper-cutting patterns in cultural and creative design is a continuation and innovative development of traditional cultural genes in modern society. This integration can offer new life to traditional art, enhance the sense of cultural identity, and promote the inheritance and popularization of culture. Through an in-depth study of the patterns, colors, compositions, and other traditional elements contained in Fuyang paper-cutting, designers can extract the core elements that best represent its cultural characteristics. Other than that, they can also combine these traditional elements with modern design concepts, materials, and technologies to create products that meet modern aesthetics while also retaining a deep cultural heritage.

Industrial Upgrading and Market Expansion

The application of Fuyang paper-cutting patterns in the cultural and creative design field is not only a cultural inheritance behavior but also a significant impetus to promoting industrial upgrading and market expansion. Thus, by combining the exquisite patterns of Fuyang paper-cutting with modern

design, the original single traditional handicrafts are transformed into creative commodities with high artistic value and cultural connotations. This includes high-end gifts and collectibles, which significantly enhance the market competitiveness and commercial value of the products.

The integration of Fuyang paper-cutting pattern elements into a modern design can successfully attract a group of young consumers who pursue personalized and high-quality life, which can broaden the market share. At the same time, Fuyang paper-cutting cultural and creative products are used in international market promotion. In addition, they also demonstrate the charm of traditional Chinese culture. They thus can promote cultural exchanges and cooperation to develop overseas markets.

Design Application Program Generation

Through the refinement and derivation of the elements of Fuyang paper-cutting patterns and combining them with the market demand, women's silk scarves are chosen as the presentation method (Figure 6). As an intangible cultural heritage, Fuyang paper-cutting can effectively spread and protect this traditional art form by integrating it into cultural and creative products. As a medium, cultural and creative products can make more people understand the cultural value of Fuyang paper-cutting.

By combining the art of Fuyang paper-cutting with modern design, new creative sparks can be stimulated to promote the application of the art of Fuyang paper-cutting innovation. Furthermore, designers can utilize the flexibility and plasticity of Fuyang paper-cutting patterns to create cultural and creative products with both traditional flavor and modern aesthetics, thus broadening the application fields of Fuyang paper-cutting art.
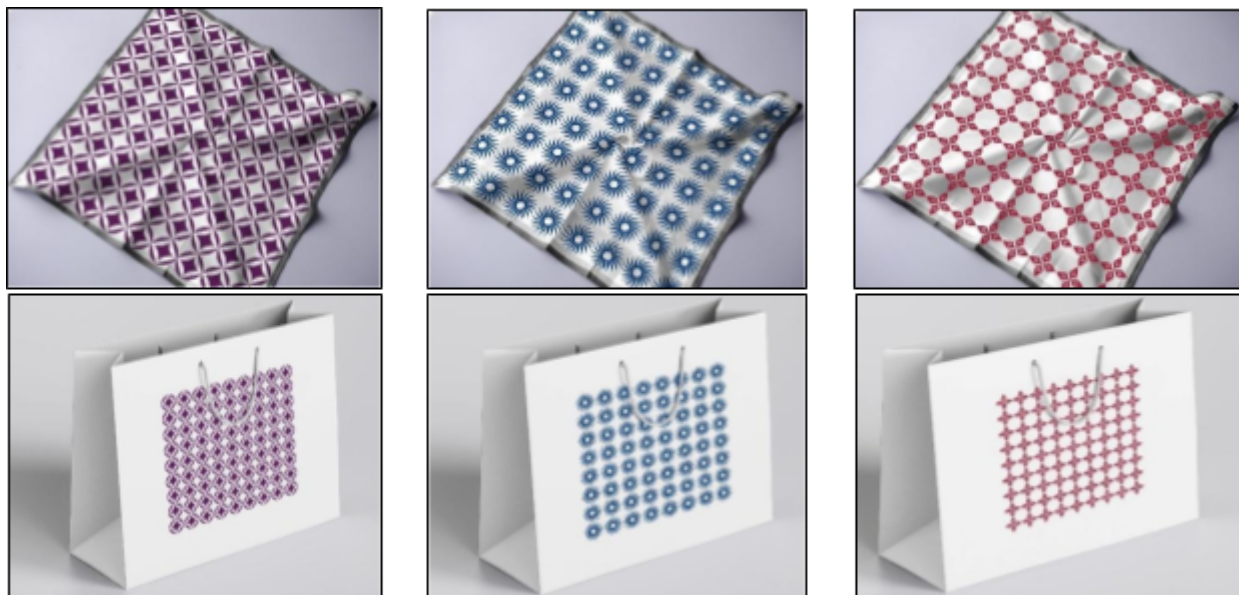

Figure 6. Application effect diagram of derivative patterns on silk scarves
(Source: Li, 2024)

CONCLUSION

SG has injected new vitality into the innovative design of Fuyang paper-cutting patterns, providing designers with systematic and structured theoretical support. It also extracts the basic morphological elements and combination rules that can be flexibly applied through in-depth analysis of pattern elements' morphological characteristics and geometric composition. This methodology effectively guides the generation of pattern design factors, enabling designers to follow the traditional aesthetic principles in the creative process and incorporate personal creativity. Accordingly, it realizes the innovative interpretation of the art of Fuyang paper-cutting.

The re-creation of Fuyang paper-cutting patterns with the help of morpho-graphic tools means that it is modernized and reconstructed to retain the traditional artistic style and cultural connotations. This novel attempt combines traditional skills and modern design concepts, offering a new life to the ancient art of paper-cutting and endowing it with a wider range of practicality and aesthetic value to make it a bridge connecting the past and the future. It also demonstrates the unique charm of the perfect fusion of traditional culture and modern design. In addition, applying morphological grammar to the design of Fuyang paper-cutting patterns also implies a living inheritance of traditional crafts. Moreover, it isolates the designer to explore and innovate on the basis of respecting and understanding the tradition and exploring more possibilities of paper-cutting art through continuous experimentation and practice. Notably, this kind of creation is based on tradition and beyond tradition, which helps to cultivate the cultural self-confidence of the new generation of designers. Additionally, it promotes the effective dissemination and sustainable development of traditional cultural resources in contemporary society.

In conclusion, integrating SG into the modern transformational design application of Fuyang paper-cutting patterns has enriched the traditional visual expression of Fuyang paper-cutting patterns and broadened its cultural dissemination and promotion pathways. It has also substantively promoted the effective dissemination and inheritance of traditional Chinese cultural resources in the contemporary context.

ACKNOWLEDGMENT

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