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DIGITAL TRANSFORMATION OF CHINESE TRADITIONAL TEXTILES: THE PRACTICE OF CREATING GENERATIVE DESIGN SYSTEMS

This paper proposes a practice-based framework for the digital transformation of Chinese traditional textile patterns. A methodological approach that combines digital tools with semiotic logic is outlined for heritage design patterns' re-interpretation in contemporary practice-based design contexts. The approach fulfils a need for generative design and cultural relevance. This study employs computational design methodologies in conjunction with design semiotics to develop digital models which transform traditional patterns into a developed grammar of form through a process of computational deconstruction and encodement. The research is presented through a series of case studies which explore the methodology's feasibility, generative potential and cultural integrity. Expert interviews and a visual preference test validate findings drawn from the research. The research results from the utilization of a parametric methodology in the design of patterns, generated with specific structural rules and varied by specific variables. The results show how technology was utilized in the culturally sensitive design for the local cultural user, more importantly the results show the enormous diversity of designs that can be generated whilst still working within the cultural remit and cultural user needs. This study develops a systematic generative approach to textile design, moving traditional and time-consuming manual replication to a computational method of design synthesis. Most importantly, novelty of this research is in establishing a connection between semiotic encoding of cultural data and parametric modelling for generation of modern textiles that function according to the logic of the culture studied. The framework provides an efficient, scalable toolkit for the fashion and digital media industries to revitalize traditional motifs. It resolves the conflict between cultural authenticity and design efficiency, offering a replicable model for the sustainable digital preservation and creative industrialization of intangible cultural heritage in a global context.

Key words: *Traditional textile patterns, Digital transformation, Generative design, Semiotic encoding, Parametric modeling, Grammar of form, Cultural heritage, Visual communications design, China.*

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ЦИФРОВА ТРАНСФОРМАЦІЯ ТРАДИЦІЙНОГО КИТАЙСЬКОГО ТЕКСТИЛЮ: ПРАКТИКА СТВОРЕННЯ ГЕНЕРАТИВНИХ ДИЗАЙН-СИСТЕМ

У статті представлена практична основа для цифрової трансформації традиційних китайських текстильних візерунків. Окреслено методологічний підхід, що поєднує цифрові інструменти із семіотичною логікою для переосмислення традиційних дизайн-візерунків у сучасних практичних дизайнерських контекстах. Цей підхід задовольняє потребу в генеративному дизайні та культурній релевантності. Робота ґрунтується на методології обчислювального дизайну в поєднанні з семіотикою дизайну для розробки цифрових моделей, які перетворюють традиційні візерунки на розвинену граматику форми за допомогою процесу обчислювальної деконструкції та кодування. Дослідження представлено серією тематичних досліджень, які демонструють доцільність, генеративний потенціал та культурну цілісність методології. Експертні інтерв'ю та тест візуальних уподобань підтверджують результати дослідження. Результати показують особливості використання параметричної методології в дизайні візерунків, згенерованих за допомогою визначених структурних правил і трансформованих за певними змінними. Доведено, що технології використовуються для створення регіонального дизайну для місцевого культурного користувача. Результати демонструють значну різноманітність дизайнерських композицій, які можна створювати, працюючи при цьому в рамках культурного контексту. Це дослідження розробляє систематичний генеративний підхід до текстильного дизайну, переходячи від традиційного і трудомісткого ручного копіювання до обчислювального методу синтезу дизайну. Новизна роботи полягає у встановленні зв'язку між семіотичним кодуванням культурних даних та параметричним моделюванням для створення сучасного текстилю, що функціонує відповідно до логіки досліджуваної культури. Такі генеративні дизайн-системи надають ефективний, масштабований інструментарій для індустрії моди та цифрових медіа з метою відродження традиційних мотивів. Вони вирішують конфлікт між культурною автентичністю та ефективністю дизайну, пропонуючи відтворювану модель для сталого цифрового збереження та креативної індустріалізації нематеріальної культурної спадщини в глобальному контексті.

Ключові слова: *традиційні текстильні візерунки, цифрова трансформація, генеративний дизайн, семіотичне кодування, параметричне моделювання, граматика форми, культурна спадщина, дизайн візуальних комунікацій, Китай.*

Problem Statement. Chinese textiles are a form of intangible cultural heritage, which is the embodiment of the sum of knowledge and experience of weavers and embroiderers over the years, a historical record of China's past, the reflection of China's ideology, art and culture, and is also a symbolic language for Chinese people to express their common values and philosophy of life. The Yunjin Brocade of Nanjing, Song Brocade of Suzhou and Shu Embroidery of Sichuan are all important components of Chinese culture that have been passed down for thousands of years (Zeng et al., 2025). Legacy of the Silk Road has become a popular topic worldwide and is highly concerned in contemporary society, representing a vital link between historical identity and modern cultural discourse.

On the one hand, it is urgent to deal with the protection of the cultural relic dissolving away due to the lapse of time and the loss of the original skill. On the other hand, it is also necessary to explore the new craft based on the silk road cultural relic in order to meet the need of creative economy (Tian et al., 2024). In addition, there are also many pressing issues related to the conservation of traditional textiles and the integration of traditional textiles into the modern creative industry (Tian et al., 2024). This means that the preservation of traditional crafts and their modernization are highly urgent, as static preservation alone cannot

guarantee the continued relevance of these motifs in a fast-paced digital market.

The art of Chinese textile craftsmanship is an important part of China's intangible cultural heritage, and therefore needs to be strongly protected. However, the conflict between traditional manual production and the requirements of modern industrialization remains a significant barrier. It is necessary to look for new ways to modernize the art of Chinese textile craftsmanship and explore the ways in which it can be integrated into the creative industry, in order to not only guarantee the survival of traditional Chinese textile craftsmanship, but also to promote the sustainable development of the textile industry through innovative design methodologies.

Analysis of research. As most of our everyday life has turned digital, digital technology seems to be the most suitable and efficient way of protecting our cultural heritage. Traditionally, the method of digital cultural heritage protection is based on the principle of digitization. Through methods like 3D scanning, high-resolution photographs, and databases, highly detailed 3D digital models of the cultural heritage can be created (Rana, 2024). Although digitizing cultural assets preserves their physical structure and form, it displays them in a static state which freezes them in time. Digitization shows the superficial structure of the pattern but does not capture the dynamic elements such as the pattern language, the semantic values of the elements, and the time-changing aspects (Ziden, 2024).

To address this gap, this paper introduces the digital transformation of heritage textile crafts and patterns with the aim of the dynamic preservation of intangible components. Digital transformation of heritage creates "living heritage" that needs to be interpreted and transformed into new contexts (Chen and Sharudin, 2023; UNESCO, 2003). In this paper, an active digital transformation of heritage (He and Gao, 2025) is presented. This shift from passive preservation to active transformation ensures that heritage remains creative and vital for use by current and future generations of stakeholders.

Traditional designs are extracted from static historical images and converted into generative design systems for use in contemporary design innovation (Hu, 2024). By deconstructing motifs into their visual and semantic components and highlighting the grammar of form, this structural information is systematically translated into a parametric model using shape grammars, ultimately forming a robust generative system capable of endless modern iteration (Hu, 2024). Such computational methods allow for the preservation of the "logic" of the design rather than just its visual appearance.

The integration of design semiotics and computational methods provides a robust framework for this transformation. Kress and van Leeuwen (Kress and van Leeuwen, 2021) describe the grammar of visual design as a set of resources for constructing meaning, which aligns with the systemic-functional semiotic model for visual imagery proposed by Riley (Riley, 2014). Furthermore, the field of cultural analytics (Manovich, 2020) suggests that large-scale cultural data, such as textile patterns, can be analyzed and visualized through computational means to reveal underlying trends and structures. This theoretical synergy enables a transition from qualitative cultural appreciation to quantitative computational logic.

Purpose of the article. The main goal of this research is to develop a practice-based framework for the digital transformation of traditional Chinese textile patterns, specifically through the creation of generative design systems. To bridge the gap between qualitative cultural appreciation and modern digital design, this study transitions from visual observation to quantitative computational logic by deconstructing traditional textile motifs into their fundamental parametric characteristics, semantic values, and grammar of form. The research aims to formulate a robust Semiotic Parametric Generative Model – Integrating mathematical functions for radial symmetry, topological matrix translation, and color mapping – to encode the implicit syntax of traditional designs into explicit computational procedures, thereby establishing an interactive generative system that enables the production of diverse modern design solutions within cultural constraints. Ultimately, this research explores the theoretical frameworks between heritage conservation and its creative utilization, ensuring that intangible cultural components are not only conserved but remain creative and vital for use by current and future generations of stakeholders.

Presentation of the main material. To address the challenges related to the creative renewal of intangible cultural heritage through digital media, a theoretical framework needs to be developed. Unlike other researches related to digital heritage, this research aims to innovate by proposing a new multi-layered framework that is applicable to the proposed methodology. The study has firstly proposed a macro model for digital transformation, and a micro model for cultural translation in heritage, thus offering a complete theoretical reference to illustrate how intangible cultural heritage products as objects can be translated into a digital, open interactive space that allows for creative activity. In current heritage studies, the primary research problem identified is that traditional digitization focuses on recording the physical form

of a building, while neglecting the 'pattern language' required for design innovation (Melnyk et al., 2025; Rana, 2024; Ziden, 2024). The essence of the solution proposed in this article involves shifting from a static digital object to a generative design device. Based on the digital transformation background explored by Russo Spena and Bifulco (Russo Spena and Bifulco, 2021) and Huang et al. (Huang et al., 2024), this research conceptualizes a three-stage progression model to structure this transformation, which are 'Digitization', 'Digitalization' and 'Digital Ecosystem' (Huang et al., 2024; Russo Spena and Bifulco, 2021). The first stage is called the Digitization stage, where the analog object such as a textile specimen is transformed into digital format by taking a high-resolution image or 3D scan (Rana, 2024). The main purpose of this stage is to preserve and make the object accessible but the outcome is limited to a static "virtual archive". Therefore, the second stage is called the Digitalization stage, representing the core transition from tradition to bespoke parametric blocks (Gill et al., 2023). In this provision, the digital information is translated into computational knowledge. This is a radical departure from earlier endeavors to digitalize heritage designs; previous studies like Huang et al. explored ways of heritage art digitalization process and methods (Huang et al., 2024). Meanwhile, techniques such as linkage editing using constrained contour lines (Bao et al., 2021) can be used to maintain the structural pattern within the parametric design system. This third stage of the constructive model is called Digital Ecosystem. The final provision of this stage sets up an interactive network around the digitalized heritage pattern. Russo Spena and Bifulco emphasize that this stage enables a collaborative environment for designers and institutions (Russo Spena and Bifulco, 2021). Recent studies propose the somatosensory interaction parameterization to design and facilitate effective design dialogues (Zhang and Guo, 2022). Thus, heritage patterns originally one-way sources of information are transformed into two-way communication channels and sources of participation and education (Yang, 2023).

The model above only shows what is happening in digital transformation. It is the concept of translation that shows how and therefore why the phenomenon can be translated or transformed in a creative way. Changing a design pattern from the past is not about copying it or even about adapting it; it is about culturally translating it (Maitland, 2017; Zhang and Rusli, 2024). Cultural translation is about transferring meaning from one culture to another. A cultural translation of a profound sort has therefore taken place when a traditional design pattern is changed from silk and the loom to pixels and computer algorithms (Zhang and Rusli, 2024). The act of translation is not about copying or imitating a design, but about translating the design to convey meaning in a new context to a new group of people. The complexities and difficulties of digital translation may be viewed from many different perspectives. According to this matter, an alternative approach is suggested using heritage translation as a lens through which to discuss the complexities of digital translation. Chen and Sharudin define heritage translation as the activity of reviving cultural products over time so that they can function appropriately in the new time period (Chen and Sharudin, 2023). Heritage translation, in this sense, is about the process of translating meanings that cross time and are readjusted in some way so that they can still function in contemporary contexts (Chen and Sharudin, 2023). In contemporary translation studies, the concept of authenticity has undergone a significant change in which the authenticity of translation is no longer associated with the preservation of the surface features of the source product, but with the translation process itself. Therefore, an authentic digital translation does not have to look similar to the source product; rather, it should use a language that 'speaks the same language' and use a modern language which replaces the outdated language in the original product. The concept of heritage translation has been adopted in the proposed model for evaluating which parts of the design patterns should be retained, and which should be changed, and for introducing new elements so that cultural products can be revived for contemporary societies while maintaining their original cultural meanings (Chen and Sharudin, 2023; He and Gao, 2025).

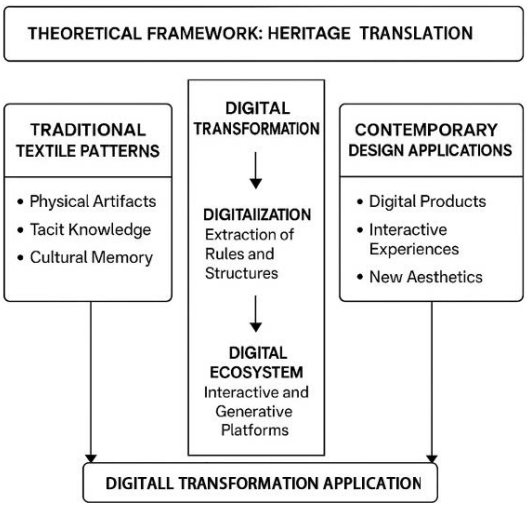


Fig. 1. Conceptual framework for digital heritage translation (created by the authors)

This figure 1 illustrates how traditional patterns (source domain) are translated via three stages of digital transformation (Digitization → Digitalization →

Digital Ecosystem) into contemporary design applications (target domain), under the overarching concept of heritage translation. The framework emphasizes moving from static digital records to interactive design systems that preserve the grammar of the original pattern.

This study is grounded in a Practice-Based Research (PBR) methodology, a well-established approach in design and the creative arts where the creative practice itself is a primary mode of investigation (Barrett and Bolt, 2010). The PBR method produces two types of research outcomes that are interdependent and form the basis of this project. The design outcomes produced by the parametric pattern system and the number of design variations it can produce, and the exegesis that explains, interprets and critically analyses the creative practice that formed the basis of the research (Candy and Edmonds, 2018). The novelty of the research lies within the digital tool developed and the artefacts produced by the tool. In addition to design outcomes, the theory that underpins the research is also an important aspect of this project (Barrett and Bolt, 2010). This study falls into the practice-based category of research, as the digital system developed is the primary method of investigation for this research (Barrett and Bolt, 2010; Skains, 2015). This research used a multi-stage hybrid research design, which involved qualitative investigation into craft practice, computational development of the digital tool using a range of methods and applications, whilst fusing 'disciplined noticing' of everyday craft practice with digital methods, as suggested by Barrett and Bolt (Barrett and Bolt, 2010). The research was undertaken in three stages: Phase 1 involved an ethnographic/iconographic investigation of the source material to understand in depth the subject matter, which was then utilized for Phase 2 constructive development of the digital tool. Phase 3 was centered on creative applications of the technology and the evaluation of the finished work (Skains, 2015), thus ensuring that the cultural aspect of the research was not lost to the technological, as advocated by Barrett and Bolt (Barrett and Bolt, 2010) and Rana (Rana, 2024). As the research team consisted of international and interdisciplinary participants, it was necessary to clarify some terms and concepts before entering into the design activity (UNESCO, 2003). Table 1 shows a bilingual glossary of the terms and expressions that were used in this study. Terminology clarification is an essential stage of the translation process and it is an integral part of the translating activity of traditional patterns.

In order to better understand the design process in generative design, several key terms have to be defined for the interdisciplinary research of this work. First, the traditional textile crafts and patterns are treated as parts of the Intangible Cultural Heritage of the corresponding cultures (UNESCO, 2003). These traditional crafts and patterns include practices, expressions and skills that are recognized as parts of a culture's heritage by the corresponding communities. In terms of patterns, a Pattern is defined as the total design system of the decorative design of a textile, including all elements and their relationships. This includes the overall aesthetic and semantic logic of the pattern. Motifs, on the other hand, are the individual elements of a pattern, such as flowers, dragons or geometric shapes (Wan and Wang, 2023; Han and Cong, 2023). These motifs are the basic elements of the pattern. In the Digitalization of traditional patterns, the elements of traditional crafts are not simply digitized but provide the possibility for design innovation by transferring traditional knowledge into computational knowledge in the digital space (Huang et al., 2024). To generate numerous design solutions within given design constraints, the elements of a model are parameterized and regulated by parameters and rules. This process is known as Parametric Design (Gill et al., 2023; Stiny, 1980). The rules of traditional designs are formalized by the Shape Grammar for the generation of new variations while keeping the rule sets of the culture's heritage strictly fixed (Hu, 2024; Stiny, 1980). The practice-based methodology is developed and applied through a structured workflow based on a parametric design approach. This workflow is used to transform a static physical textile pattern into a ruled based generative model (He and Gao, 2025). The resulting 'transparent black box' offers a structured and rigorous creative process based on the grammar of form that results in a digital model that is firmly rooted within the heritage it is derived from (He and Gao, 2025).

The design strategy is split into three progressive stages which form the complete pipeline from analysis of a traditional syntax to the generative implementation and finally interactive application of a parametric design model (Fig. 2). Which consists of Stage 1: Parametric Feature Extraction and Semantic Definition, Stage 2: Generative Parametric Modeling with Shape Grammars, and Stage 3: Interactive Parametric Implementation and Application, flowing from left to right. User defined parameters and generative rules move the process from analyzing the traditional syntax to developing a robust generative system and finally to applying the model in a modern design context).

In the analytical analysis of Stage 1, the parametric characteristic of the source textile is analyzed and recorded through high resolution pictures (Panofsky,

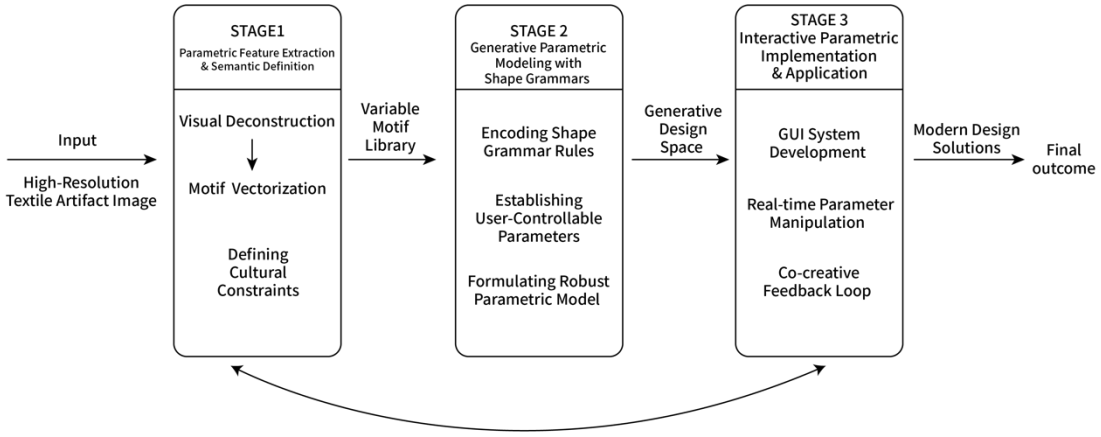


Fig. 2. Stages of the Parametric Design Workflow for Generative Pattern Systems (created by the authors)

1983). The pattern is divided in motifs and subordinated elements. Through the visual semiotics these motifs and subordinated elements are interpreted as signs with semantic value (Kress and van Leeuwen, 2021; Riley, 2014). They are rasterized and also vectorized in order to create variables that can be stretched and scaled as Scalable vector graphics (SVGs) within the parametric system (Manovich, 2020). Additionally, the motifs are semantically annotated with the "cultural constraints" to generate the "auspicious cloud" (祥云 xiángyún) within the rules of the digital library for the generation of textiles. Moving to Stage 2, a generative parametric model is developed that encodes deconstructed motifs and rules derived from heritage traditional surface ornamentation into a parametric model. A shape grammar is used as a formal rule system that encodes spatial relations between vectorized motifs (Stiny, 1980). The motifs are evolved from traditional patterns into bespoke parametric blocks (Gill et al., 2023). An explicit syntax is created that follows the logic of the artisans that originally hand crafted the heritage surfaces (Hu, 2024). Links are made between the rules in the shape grammar to user-controllable parameters. A small number of parameters control attributes such as motif frequency, randomness in size, spacing between motifs and colour palettes. Design solutions are generated that strictly fall within the cultural constraints of the original heritage tradition (Hu, 2024; Stiny, 1980). In doing so, the heritage tradition is transformed into a design space that can be explored in depth to generate an infinite number of design variations. The last stage of the design process, Stage 3, is the implementation of the developed parametric model into an interactive user-focused system. The interactive system is a freestanding application consisting of a Graphical User Interface (GUI) that allows designers to manipulate generative parameters such as density and scale or toggle different motifs (He and Gao, 2025). This interactive system is often implemented using real-time graphics programs such as Unity or TouchDesigner (He and Gao, 2025). The application developed for this research includes feedback derived from the semantic definition created in Stage 1 of the design process. The application provides the designer with cultural-based cues as they design within the system in real time. By combining the creative skills of a designer with the computational power of the system, a truly co-creative process was set up to rapidly produce modern designs derived from traditional ancient patterns, while maintaining the cultural roots intact (Candy and Edmonds, 2018; Yang, 2023).

The practical implementation of the proposed framework is demonstrated through a comprehensive case study: the digital reinterpretation of a classical Chinese silk brocade featuring floral medallions and lozenges. This specific textile, a hand-woven textile with floral medallions and lozenges typical of classical Baoxianghua brocade. Patterns made up of floral roundels or ogival medallions set within a lattice of lozenges are examples of traditional Chinese textile patterns of the Tang and Song dynasties and beyond. The study textile combines composite lotus-and-peony blossoms, cloud-scroll motifs and palmettes with pearl roundels. These patterns are more representative of broader patterns of traditional Chinese textile patterns than of specific regional or ethnic styles, and therefore are well chosen as an example for the digital translation framework proposed in this study.

Fig. 3. Original Textile with floral medallions and lozenges, Tang dynasty, Source from Smithsonian Institution (National Museum of Asian Art, n.d.)

The reference artifact is a silk brocade panel featuring repeating floral medallions set at the intersections of a diamond-shaped (lozenge) lattice. The medallions consist of stylized Baoxianghua motifs surrounded by smaller filler flowers and cloud-like scroll designs. These are placed on top of a background of continuous diagonal bands of the lozenges which are often reinforced with contrasting weft colours (Fig. 3). Motifs derived from high resolution photographs of the textiles are deconstructed in Stage 1 Motif Extraction.

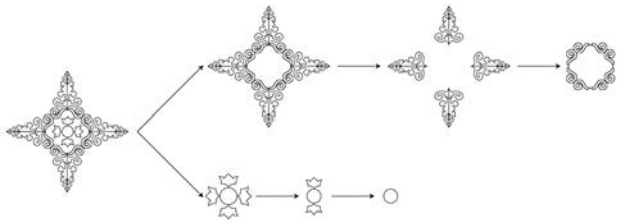


Fig. 4. Extraction and Decomposition process of traditional pattern elements (created by the authors)

From the reference artifact, the pattern was decomposed into several key motif categories (Fig. 4):

1) Central floral medallion (Baoxianghua). The central round or lozenge-shaped floral medallion motif is formed from innumerable stamens and petals of various flowers and buds and leaves in scroll form. The theme of the Baoxianghua is derived from the Chinese concept of being surrounded by abundance and being content. It can also be interpreted as the Buddhist treasure flower symbol of the ideal pure land.

2) Secondary filler motifs. Other motifs such as four-petal flowers, cloud scrolls and stylized buds are distributed in the fields between the medallions. Their purpose is to soften the rigidness of the grid and add decoration on the surface of the wall with a dynamic arrangement of motifs distributed in a harmonious manner throughout the whole panel. The latter are symbolic of eternal stability, good fortune and the change of seasons.

3) Lozenge lattice. A network of diagonal bands creates a continuous field of rhombus-shaped cells. This lattice does not merely provide structure; it symbolizes order, stability, and an infinite extension of auspicious motifs across the textile surface.

Using Adobe Illustrator, each component was carefully traced into clean vector graphics. The central floral medallion, secondary blossoms, cloud scrolls, and lozenge units were each stored as separate vector motifs. At the same time, semantic annotation was applied: the medallion was tagged with “abundance, protection, cosmic center,” filler blossoms with “renewal, rhythm,” cloud scrolls with “continuity, auspiciousness,” and the lozenge lattice with “order, extension, structure.” This procedure created a digital motif library in which each element carries both visual form and cultural metadata, ready for parametric recombination.

Figure 5 presents the main vector motifs isolated from the brocade: (a) the composite Baoxianghua floral medallion; (b) secondary four-petal blossoms and cloud scrolls; and (c) a single lozenge unit extracted from the lattice. Each vector element is accompanied by its semantic tags (e.g., “abundance, center” for the medallion; “renewal, rhythm” for the filler blossoms; “order, extension” for the lattice). These annotated motifs form the basic vocabulary of the generative pattern system.

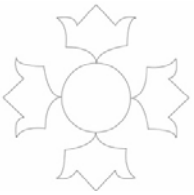
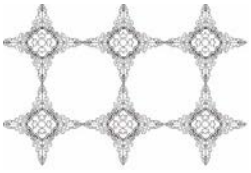
	The composite Baoxianghua floral medallion	Abundance, center
	Secondary four-petal blossoms and cloud scrolls	Renewal, rhythm
	A single lozenge unit extracted from the lattice	Order, extension

Fig. 5. Deconstructed vector motifs and semantic labels (created by the author)

Stage 2 of Generative Pattern Creation used the motif library to formally define a shape grammar for the compositional rules of classical floral-and-lozenge brocades. In the reference textile, the repeating medallions are located at the nodes of the diagonal lattice and the secondary blossoms and scrolls that fill the spaces between them. The following production rules were derived:

1) Medallions can be centered at intersections of the lozenge cells, or at the centers of the cells themselves, as long as the tiling appears unbroken.

2) Secondary motifs may be added to the spaces between the lattice bands or to the lozenges and arranged using principles of both bilateral and four-fold symmetry and balance.

3) The lozenge lattice defines the underlying geometry and may be explicitly visible (contrasting color bands) or implied through alignment of motifs.

These rules are linked to a set of user-controllable parameters, including medallion scale, lattice density (distance between intersections), proportion of filler motifs, and color palette (e.g., traditional combinations such as blue-and-gold or red-and-green versus simplified monochromes). By adjusting these parameters, the system generates a wide range of pattern variants. All outcomes remain "grammatically correct" because they respect the underlying structural relations between medallions, lattice, and fillers derived from the historical model (Fig. 6).

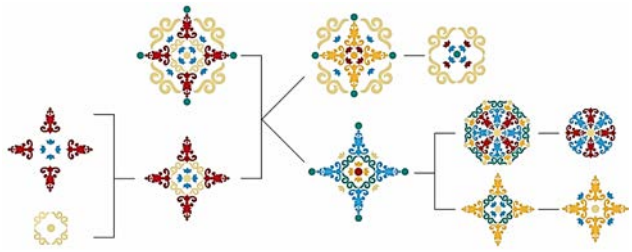


Fig. 6. Parametric variations of the floral-and-lozenge brocade (created by the authors)

Four different results from the generative system are shown in Figure 5 as examples of generated patterns. The designs vary in degree of historical motif reproduction, size of elements, and ornamentation. In (a), historical brocade motifs are densely interwoven with full colour and high colour saturation using bright reds, blues and golds. In (b), the size of the central flowers is increased and the filler motifs are made much smaller in order to further accentuate the central motifs. In (c), the high-contrast lattice is made more visible. In (d), a minimalist design is created with three colours and simple outlines on the medallions. Together, these variants demonstrate how the parametric model can explore a broad design space while retaining the essential "grammar" of floral medallions embedded in a lozenge grid.

For relevance to today's world of Modern Application as the last stage, one of the computational patterns was applied to the design of a fashion silhouette for today using 3D artifact simulation software (CLO3D). The second pattern is the slightly larger Baoxianghua medallions on a very minimal lozenge framework but in a muted palette of ancient silk fabric colours – deep blue and gold which are appropriate for modern minimalism tastes. This pattern is applied to a modern interior textile with a simple modular panel structure of lines. The computation of medallions' arrangement on the seams and body surface is such that the motifs always fall on the more visible surfaces of the textiles (front panels and back). This example shows how the traditional logic in the design of luxurious fabrics such as brocade could be reinterpreted to create a new, refined, global textile material that could be used in contemporary textile design and applied to multi-fields of design productions such as casual wear.

A simulated textile made from digital translation of the brocade pattern shown in Figure 7. The Medallions and lozenges follow a rhythmic sequence which encircles the three-dimensional form of the structure, while at the same time preserving the intricate detail and contemporary simplicity. It has been demonstrated that the digital pattern translation framework has a direct applicability in interior design and there-

1 2 3

Fig. 7. Application of a generated floral-and-lozenge pattern on modern artifact (3D render, created by the authors)

fore in other areas of design such as accessory design, fashion design and user interface design.

To examine how meaning evolves through digital translation, the original brocade and one selected translated pattern were compared using Semiotic Transformation Analysis. The focus was on whether key symbolic associations of the Baoxianghua system are preserved, transformed, or expanded in the contemporary design. As the primary subject of this analysis, the Baoxianghua system represents a complex cultural entity where religious and aesthetic values are synthesized into a highly integrated ornamental structure. The evolution of this entity is mapped through five core semiotic elements (a-e) as visualized in Figure 8: (a) Baoxianghua floral medallion: 'treasure flower' symbolizing good fortune and idealized cosmic order; in the digital model, this complex composition is reduced to an iconic stylized floral motif that conveys a universal message of 'timeless elegance'. Although less religious than its traditional counterpart, it still references Chinese art and culture (He and Gao, 2025). (b) Lozenge lattice: provides secondary support to the floral motif creating a continuous diagonal grid that symbolizes eternal stability and infinite extension. In the parametric model this lattice can be made visible and manipulated to create an underlying rhythm that highlights modern geometry or pushes the floral motifs to the foreground. (c) Secondary blossoms and scrolls: symbolizing vitality and seasonal renewal, these elements are treated as being of less importance than the floral motifs and can be easily switched on or off; frequency and randomness of elements can also be varied. They are a more reduced version of the original but packed with rhythm and movement. (d) The colour palette changed from a very rich and multi-coloured palette referring to ceremonial practices and opulence to a design parameter to offer traditional palettes in a more subdued or monochromatic way with influences from different cultures and a lot of design options for modern, global and minimalistic environments (Chen and Sharudin, 2023). (e) Composition-wise the design changed from a dense field of continuous prosperity to a system that offers controlled negativity or 'breathing space'. The pattern interprets the heritage of prosperity in a modern context and finds a balance between well-being and minimalism (Chen and Sharudin, 2023; He & Gao, 2025).

To precisely formalize this visual semiotic transformation into a computational language, a Semiotic Parametric Generative Model is constructed. As illustrated in Figure 8, this transformation process is operationalized through three core computational modules:

1) Primitive Radial Symmetry: The structural core of the traditional Baoxianghua motif is characterized by multi-order radial symmetry. The deconstructed core semiotic primitive is defined as a set E. Let the rotation angle parameter be θ, with the corresponding 2D rotation matrix $R(\theta)$. For a Baoxianghua motif exhibiting $N-$order rotational symmetry, the generative equation for the complete individual motif M is formulated as:

$$M = \bigcup_{i=0}^{N-1} \left(\begin{bmatrix} cos\left(\frac{2\pi i}{N}\right) & -sin\left(\frac{2\pi i}{N}\right) \\ sin\left(\frac{2\pi i}{N}\right) & cos\left(\frac{2\pi i}{N}\right) \end{bmatrix} \cdot E \right)$$

2) Topological Matrix Translation: Upon generating the individual motif M, it is distributed across a 2D canvas according to the skeletal structures of the lozenge lattice. Assuming the horizontal spacing parameter is d_x and the vertical spacing parameter is d_y, the generative function for the overall pattern matrix P_{total} controlled by a translation vector T is expressed as:

$$P_{total} = \bigcup_{u=0}^{U} \bigcup_{v=0}^{V} T(u \cdot d_x, v \cdot d_y) \cdot M$$

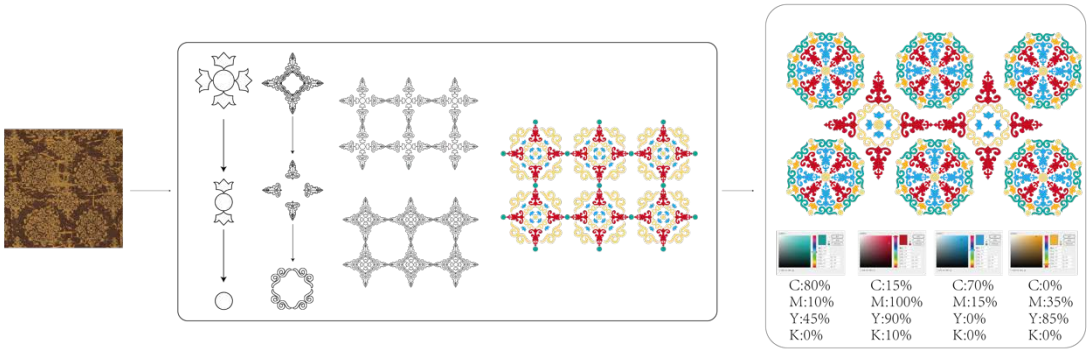


Fig. 8. Visual Semiotic Transformation: From Traditional Baoxianghua Motifs to Parametric Variables (created by the authors)

3) Color Variable Mapping Model: To ensure design variability and cultural consistency, colors are defined as parametric vectors mapped to specific semiotic primitive groups. Let the $j-$th structural hierarchy of the motif be denoted as S_j. Its corresponding color variable is defined as a four-dimensional vector $C_j\left(c_j, m_j, y_j, k_j \leq 100\right)$. The color mapping function $f\left(S_j\right)$ automatically applies specific color configurations to each topological hierarchy, enabling the rapid color iteration depicted on the right side of Figure 8.

$$C_j = \begin{bmatrix} c_j \\ m_j \\ y_j \\ k_j \end{bmatrix}, where 0 \leq c_j, m_j, y_j, k_j \leq 100$$

Governed by these mathematical functions, the illustration of the deconstruction of the source pattern into 5 semiotic elements shown in Figure 8 is effectively translated into a digital design system and developed into contemporary aesthetic design outputs. The original handmade pattern on the left serves as the source material, the parametric rules for transformation are in the center, and the generative designs which have been created from them are on the right.

The work shows how traditional cultural symbols can be reinterpreted and remapped into a contemporary design system. Translation of content into a modern design language is here far from being neutral. While keeping the substance of the contents merely in focus, the core of the content, namely the concepts of prosperity, harmony and ordered abundance, were re-interpreted through the manipulation of algorithmic variables in a modern design language corresponding to contemporary designs. The Baoxianghua system thus remains recognizable while gaining new expressive potentials in modern design contexts.

By employing the results of the case study in the field of heritage translation may shed light on the conservation of intangible cultural heritage, creative practice and design education. With this respect, the discussion will relate the project's findings to the issue of bridging traditional textile heritage and modern digital design practices which was introduced in the foreground of the study.

Heritage Preservation through Active Reinterpretation. Heritage preservation practices always record the past designs of different culture in a passive manner, which cannot connect the past with the present design profession. Through generating dynamic generative patterns based on traditional designs, our research is trying to produce a form of "living heritage" that can bridge the past, present and future by enabling people to participate in the production of culture and design by design reinterpretation (He and Gao, 2025). Different from the traditional way of recording the past culture and design into static exhibits or digital databases in the museum, the method we propose here allows young designers to remix and reinterpret heritage designs by participating in cultural activities, which in turn promotes cultural confidence, so as to make traditional designs keep up with the pace of the time (Huo and Skliarenko, 2024). This is also a more sustainable method of cultural preservation, through which cultural heritage can become part of contemporary culture in a dynamic manner, rather than being kept as a static artifact (Rana, 2024). In this way, the dynamic design platform works as an archive, but instead of keeping the past historical artifacts, it records the design as a set of dynamic rules and patterns, design potentials.

Expanding Creative Practice. Using computational techniques, the parametric system can be seen as a tool to assist the creative practice of textile designers. The designer begins designing from an almost infinite space of design options which are provided by the computer as opposed to designing one repeat pattern from scratch. The human creativity of the designer is not diminished but in fact supported by technology in a co-creative relationship (Candy and Edmonds, 2018). One can perhaps describe the textile designer as being like a gardener. The gardener sets up parameters or rules that will determine how the garden will grow and plants or seeds the garden with a number of motifs and parameters. By tending to the garden and pruning the designs, the gardener nurtures the best designs to further evolve (Candy and Edmonds, 2018). Barrett and Bolt found that digital tools are used to assist our creative practice by allowing us to explore and visualize the impact of design ideas that can be used to enhance our designs (Barrett and Bolt, 2010). The system allows for instant feedback, as designers can play and experiment in a creative space in an improvisational manner (Barrett and Bolt, 2010). The expressive freedom provided by the interactive system will allow designers to arrive at design solutions that may not have been possible by other manual methods.

Audience Engagement and Education. Furthermore, the participatory aspect of the system will engage the audiences at various levels. As users of the system, the designers will benefit from the system in terms of increased participatory engagement in the preservation of cultural heritage. On the other hand, members of the public who are not familiar with the traditional patterns will have the opportunity to experience the system through exhibitions and workshops

which serve as an interface for education and learning. The participatory aspect of the system serves as an educational tool that bridges the gaps between culture and heritage and audiences and communities. Through this system, participants interact and connect with the patterns and receive feedback from the culture, thus creating a personal link with the heritage in an empowering, culturally aware, emotionally connected and confident way of engagement and participation in their own cultural heritage (Yang, 2023). This is very different from the role of being a spectator observing the cultural objects in a museum from a distance and behind the glass case of a pedestal. Heritage participants in this system will act as narrators of their own heritage and connect and engage with the traditional patterns they have no knowledge of, and with which they are not familiar or have never engaged or related with (Ziden, 2024). In this way, cultural heritage will shift from being an object of admiration to becoming an object of experience.

Redefining Authenticity in the Digital Age. Ultimately, authenticity is an important issue in the reproduction of replicas of cultural heritage artefacts such as textiles and in digital reconstructions derived from 3D scanning of artefacts. Smith defined replicas and translations of artefacts as not authentic because they do not carry cultural meaning and they are not related to the original context (Smith, 2007). Using the principle of heritage translation as a different perspective to authenticity may be more fitting. An authentic digital translation cannot be seen as a simple visual copy of the original heritage artifact. In practice and in theory, it is logically impossible. Objects cannot be classed as authentic objects in the way that a human being can. According to Chen and Sharudin, an authentic digital translation can be created if one carefully examines the formal and symbolic elements of the original motif and exercises professional discretion in deciding what to keep, change or lose (Chen and Sharudin, 2023). Thus, an authentic digital translation can be created using our technology, provided that one accepts that authenticity means that it shares the same visual language as the original design but with a different "accent" or pronunciation – in a similar way to what He and Gao describe ascribed to the term "heritage translation" (He and Gao, 2025).

The designer in the digital age is a cultural mediator, a bridge between the past and the present, between tradition and technology. This model illustrates this role. Having knowledge of cultures and being aware of the potential of computer technology, the designer guarantees the conservation of the designs, while presenting them as current, relevant and innovative designs for a new era and on new surfaces for a new public.

Conclusion. This paper discusses the collaborative design of text and icons in signage for child-friendly spaces and analyzes the problem of information communication in children's spaces from the perspective of text–image interaction. Through the comparison and induction of representative cases, the paper summarizes the interaction between text and icons into three main types: confirmation-oriented, semantic-cohesive, and experience-participatory. These three types correspond respectively to the three core needs involved in children's spatial reading rapid recognition, stable understanding, and active approach, showing that text and icons are not simply juxtaposed, but together constitute an important visual unit through which children understand spatial information.

From an overall perspective, the collaboration between text and icons in signage for child-friendly spaces is not primarily manifested in synchronized changes at the level of form, but rather in a configurational mode of collaboration: text provides a stable framework for reading and hierarchical order, while icons undertake the functions of differentiated recognition, semantic cueing, and situational participation. This result indicates that what truly affects children's use of signage is not the individual element itself, but whether a clear, stable, and cognitively appropriate interactive logic is established between text and icons. Based on this understanding, signage design in child-friendly spaces should give priority to clarity of recognition, strengthen the semantic consistency between text and icons, and adjust the relative prominence of text – image relationships according to different spatial nodes.

At the theoretical level, this paper defines the text–icon relationship in signage for child-friendly spaces as a design issue worthy of independent discussion, and, on the basis of comparative case analysis, proposes three collaborative types with explanatory value. At the practical level, the findings may provide a reference for signage optimization in children's hospitals, children's libraries, parent–child service spaces, and integrated play environments. It should be noted that this study is mainly based on case analysis and visual induction, and has not yet been validated through behavioral observation or comprehension testing with child users. Future research may further incorporate empirical data from children of different age groups in order to examine more deeply the differences among various text – image combination modes in terms of recognition efficiency, semantic comprehension, and emotional experience.

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