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APPLICATION OF GENERATIVE AI MODELS IN DECONSTRUCTION AND INNOVATIVE DESIGN OF TRADITIONAL PATTERNS FOR SHU EMBROIDERY FANS

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Abstract:

This research endeavors to address the challenges of intergenerational inheritance and to advance Shu embroidery by exploring the use of generative Artificial Intelligence (AI) to deconstruct and design innovative traditional Shu embroidery fan patterns. A triphasic AI-driven methodological framework was formulated, encompassing AI-facilitated pattern deconstruction and domain-specific dataset construction. The framework also included optimizing the Stable Diffusion model via Low-Rank Adaptation (LoRA) fine-tuning and a comprehensive assessment of AI-generated patterns, integrating objective metrics (Inception Score [IS], Fréchet Inception Distance [FID]) and subjective evaluation protocols. Empirical findings demonstrate that the optimized model proficiently captures the stylistic essence of traditional Shu embroidery. The model also attains substantial innovations in pattern elements, compositional structures, and color harmonization, thereby striking a balance between heritage preservation and creative advancement. Overall, the research concludes that generative AI serves as a pivotal driver of innovation in Shu embroidery fan patterns, offering a technical paradigm for the organic integration of inheritance and innovation in the protection and development of Intangible Cultural Heritage (ICH).

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Traditional Pattern; Innovative Design; Inheritance And Innovation; Generative AI; Shu Embroidery Fan



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Introduction

As one of China's Four Great Embroideries, Shu embroidery boasts a time-honored history spanning three millennia and is acclaimed as the "Gem of Shu," embodying profound cultural significance and exquisite artisanal craftsmanship. Shu embroidery fans, as quintessential carriers of this artistic form, integrate utilitarian functions with aesthetic values. Their traditional motifs, encompassing floral, avian, ichthyic, entomological, and other thematic categories, serve as crucial repositories of cultural symbols, mirroring the aesthetic pursuits and cultural ethos of the Chinese nation. Nevertheless, amid the tide of modernization and globalization, traditional Shu embroidery fan patterns face formidable obstacles to inheritance and development. On the one hand, the creation of traditional patterns relies heavily on craftsmen's accumulated experiential knowledge, requiring prolonged skill acquisition and, consequently, leading to a scarcity of inheritors. On the other hand, conventional patterns fail to meet the diverse, personalized demands of contemporary consumers, thereby undermining the market competitiveness of Shu embroidery products.

The rapid advancement of generative Artificial Intelligence (AI) has opened up novel prospects for the innovation of Intangible Cultural Heritage (ICH). Core models such as Generative Adversarial Networks (GANs) and diffusion models can assimilate the stylistic characteristics of traditional cultural patterns through deep learning algorithms. These models enhance design efficiency and enable creative output that transcends the limitations of manual craftsmanship. Additionally, the academic community has increasingly focused on applying generative AI to traditional textile pattern design, yielding favorable outcomes in cultural preservation and market adaptability. However, scholarly inquiries into the application of generative AI to Shu embroidery fan patterns remain relatively scarce, particularly in the realms of AI-aided pattern deconstruction and integrated pattern-color innovation, which has constrained the efficacy of AI in advancing the development of Shu embroidery. Consequently, exploring the mechanism by which generative AI drives the innovative design of Shu embroidery fan patterns assumes paramount significance. It directly addresses the inheritance and development challenges of Shu embroidery fan patterns identified above and bridges the chasm between AI technology and the modernization requirements of Shu embroidery.

Against this backdrop, the present study focuses on investigating the role of generative AI models in driving the innovative design of traditional Shu embroidery fan patterns and clarifying the underlying innovation mechanisms and practical value. To address the

aforementioned research gaps and predicaments, the specific research objectives are delineated as follows:

- 1) Develop an AI-aided deconstruction methodology to extract the stylistic attributes and color principles of traditional Shu embroidery fan patterns, and establish a high-quality domain-specific dataset;
- 2) Optimize generative AI models to achieve a harmonious balance between traditional inheritance and innovative creation, thereby enabling precise pattern generation;
- 3) Construct a comprehensive evaluation system centered on innovation performance to validate the application value of AI-generated patterns.
- 4) These objectives form a logical chain of "problem diagnosis-data foundation-model optimization-effect verification," which directly targets the core issues of insufficient AI application in Shu embroidery fan pattern research and the lack of targeted model optimization. By addressing these issues, this research aims to overcome the limitations of traditional manual design, promote the in-depth integration of Shu embroidery art with AI technology, and provide a reference paradigm for the innovative development of other ICH forms.

Literature Review

AI-Assisted Deconstruction and Digitization of Traditional Embroidery Patterns

The deconstruction of traditional embroidery patterns serves as the fundamental premise for digital inheritance and innovative design, and the integration of AI technologies has substantially enhanced the efficiency and precision of this process. This approach is particularly relevant to the first research objective of this study, as high-quality deconstruction lays the data foundation for subsequent model training. Moreover, academic scholars have progressively shifted from conventional manual analytical approaches to AI-augmented methodologies, integrating iconographic and semiotic theories with advanced AI tools. For instance, Zheng and Saelee (2025) utilized AI image recognition to conduct an in-depth analysis of the design elements of Shu embroidery, thereby improving the accuracy of element extraction. The Hill Publishing Group (2025) proposed an AI-facilitated digital extraction framework for traditional patterns, grounded in deep learning and computer vision technologies, enabling automated, efficient recognition of pattern features.

These scholarly endeavors validate the feasibility of AI-aided deconstruction in embroidery-related research. They also lay a solid foundation for the deconstruction and digitization of traditional Shu embroidery fan patterns in this study, furnishing crucial support for subsequent AI model training and innovative generation.

The Core Role of Generative AI in the Innovation of Traditional ICH Patterns

Generative AI has emerged as a core driver of ICH innovation, exhibiting remarkable potential for pattern innovation and stylistic breakthroughs. This aligns with the second research objective of this study, which focuses on model optimization for innovative pattern generation. Diffusion models and GANs have reshaped the landscape of traditional craft pattern design by transcending the inherent limitations of manual creation. For instance, Li et al. (2025) combined the Stable Diffusion model with Low-Rank Adaptation (LoRA) fine-tuning to

generate innovative Miao embroidery patterns that incorporate contemporary aesthetic elements. Wang et al. (2025) employed a fine-tuned diffusion model to generate novel kite patterns, facilitating the innovative development of this traditional craft. Furthermore, Khamraeva (2025) achieved the innovative integration of traditional embroidery art with modern computational design through generative AI. These studies confirmed the effectiveness of diffusion models and LoRA fine-tuning in traditional craft pattern innovation, providing a technical reference for this study's model optimization approach.

Nevertheless, the application of generative AI in Shu embroidery remains in its nascent stage, with a dearth of targeted research focusing on model optimization to enhance the innovation of Shu embroidery fan patterns. This deficiency has hindered the full exploitation of AI's innovative potential in this domain, underscoring the need for the model optimization work proposed in this study.

AI-Driven Color Innovation in Traditional Embroidery Patterns

Color harmonization is a pivotal component of the artistic value of traditional embroidery. Color innovation, on the other hand, plays a crucial role in enhancing its appeal to contemporary consumers, complementing the integrated pattern-color innovation requirement implied by the second research objective. Shu embroidery is characterized by an elegant, harmonious color palette with rich gradations.

In the digital era, AI technologies provide robust support for traditional pattern color matching, and generative AI demonstrates distinctive advantages in intelligent color innovation while adhering to traditional aesthetic principles. Relevant studies have used machine learning algorithms to analyze traditional color rules and implement innovative color-matching strategies that balance traditional heritage and modern aesthetics. However, research on generative AI-based color innovation specifically for Shu embroidery patterns is inadequate. Hence, it fails to develop a tailored AI-driven color innovation mechanism that meets the requirements of integrated pattern-color innovation in Shu embroidery fan design. This research gap further justifies the focus on color innovation analysis in the subsequent results and discussion sections of this study.

Methodology

To attain the aforementioned research objectives and address the identified research gaps, this study adopts a mixed-methods approach integrating quantitative and qualitative methodologies, widely recognized as effective for complex research scenarios involving technical optimization and aesthetic evaluation. This study also incorporates the Design-Based Research (DBR) methodology, which emphasizes iterative improvement through cycles of design, implementation, evaluation, and revision, making it suitable for the phased model-optimization and pattern-generation process.

Based on these methodologies, a triphasic AI-driven research framework was established, which corresponds logically to the three research objectives. The first phase (AI-facilitated pattern deconstruction and dataset construction) addresses Objective 1 by laying the foundation for innovation through high-quality, domain-specific data. The second phase (optimization of generative AI models) achieves Objective 2 by enhancing the model's adaptability to Shu

embroidery patterns and improving its innovative capabilities. The third phase (comprehensive evaluation of AI-generated patterns) fulfills Objective 3 by verifying whether the model meets the dual requirements of inheritance and innovation through an innovation-centered evaluation system. The detailed procedures of this framework, which form a coherent research chain from data preparation to model optimization and effect verification, are elaborated as follows.

AI-Assisted Pattern Deconstruction and Dataset Construction

Initially, 200 samples of traditional Shu embroidery fan patterns covering five thematic categories were collated from museums, cultural heritage preservation institutions, and private collections. Specifically, these samples underwent deconstruction using AI image processing tools from three-dimensional perspectives, including pattern elements, compositional rules, and color characteristics. First, core and auxiliary pattern elements were extracted through AI-based image segmentation techniques. Subsequently, layout configurations and proportional relationships were analyzed utilizing AI shape recognition algorithms. Color values and coordination rules were documented by integrating a colorimeter with AI color analysis tools. Ultimately, the deconstructed data were systematically organized and annotated to establish a specialized Shu Embroidery Fan Pattern Dataset (SEFPD) that meets the input requirements of generative AI models.

Optimization of Generative AI Models for Innovative Design of Shu Embroidery Patterns

The Stable Diffusion model was selected as the baseline model due to its robust generative capabilities and favorable controllability. LoRA fine-tuning was implemented to optimize the model, enhancing its innovative generation capabilities while maintaining stylistic consistency with traditional Shu embroidery. The specific optimization steps are as follows: (1) Data preprocessing: Images in the SEFPD were standardized to a resolution of 512×512 pixels, and data augmentation techniques were employed to expand the dataset scale; (2) Parameter configuration: Optimal hyperparameters were determined through iterative experiments, specifically a learning rate of 5e-5, a batch size of 8, and 50 training epochs; (3) Model training: Preprocessed data were fed into the model for fine-tuning, with parameters optimized by minimizing the loss function; (4) Model validation: 20% of the dataset was designated as the test set to evaluate the model's generative performance and innovation level.

Evaluation of Innovation Performance of AI-Generated Patterns

A comprehensive evaluation system centered on innovation performance was established, integrating objective metrics (Inception Score [IS] and Fréchet Inception Distance [FID]) and subjective assessment procedures. Notably, a higher IS value indicates superior quality, diversity, and innovation in the generated patterns, while a lower FID value indicates greater similarity with traditional samples, reflecting stronger inheritance of traditional styles. The subjective evaluation was conducted by a professional panel comprising five Shu embroidery craftsmen, five design experts, and 20 consumers, using a 5-point Likert scale to assess three key dimensions: stylistic consistency, aesthetic value, and innovation. The Likert scale was selected for its high reliability and validity in subjective aesthetic evaluation of cultural products. Consequently, the final evaluation result was derived from the weighted average of the objective (40%) and subjective (60%) scores, ensuring an accurate and comprehensive assessment of the model's innovation performance.

Research Variables and Hypotheses Centered on Generative AI

The independent variable in this study was the optimized generative AI model, while the dependent variables were the performance metrics of AI-generated patterns (core metric: innovation level; supplementary metrics: stylistic consistency, aesthetic value). Moreover, control variables included the number of training samples and model parameters. These variables are closely aligned with the research objectives, which aim to verify the model's capacity to balance inheritance (measured by stylistic consistency) and innovation (measured by innovation level). Based on this, three research hypotheses were proposed:

- H1:** The optimized generative AI model is capable of generating patterns that conform to the stylistic norms of traditional Shu embroidery.
- H2:** Patterns generated by the optimized model exhibit distinct innovative characteristics in comparison to traditional manual designs.
- H3:** The innovative color coordination of AI-generated patterns adheres to the aesthetic principles of traditional Shu embroidery.

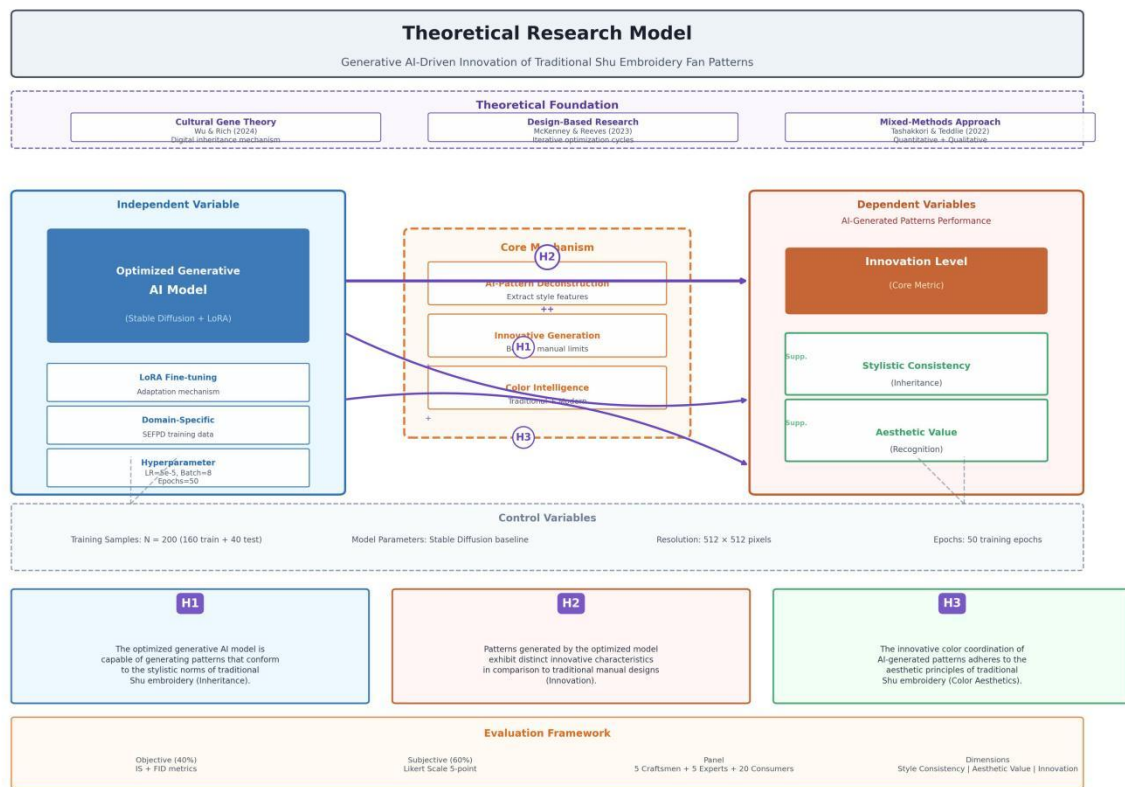


Figure 1: Theoretical Research Model

Results and Analysis

Construction of Shu Embroidery Fan Pattern Dataset (SEFPD) for AI Training

Following the collation and deconstruction of 200 traditional Shu embroidery fan pattern samples, the SEFPD tailored for generative AI training was successfully established. This

dataset comprises 160 training and 40 test samples across five thematic categories. The SEFPD directly addresses the technical foundation requirements of the subsequent model-optimization phase (Objective 2) and provides standardized data to verify the proposed research hypotheses. The detailed composition of the dataset is presented in Table 1.

Table 1. Composition of Shu Embroidery Fan Pattern Dataset (SEFPD)

Theme Category	Number of Training Samples	Number of Test Samples	Proportion of Total Samples (%)	Main Pattern Elements
Flowers	42	8	25	Peony, lotus, plum blossom
Birds	38	10	24	Phoenix, magpie, mandarin duck
Fish and Insects	30	6	18	Carp, butterfly, dragonfly
Auspicious Animals	32	8	20	Dragon, lion, kylin
Others	18	8	13	Clouds, waves, geometric patterns
Total	160	40	100	-

Optimization Results of Generative AI Models for Innovative Pattern Generation

To validate the efficacy of the optimized model in generating innovative Shu embroidery fan patterns, a comparative analysis was conducted between the original and optimized Stable Diffusion models on the test set using IS and FID metrics. As aforementioned, a higher IS value denotes superior quality, diversity, and innovation, while a lower FID value indicates greater similarity to traditional samples. The comparative results are presented in Table 2.

Table 2. Performance Comparison of Different Generative AI Models

Model	Inception Score (IS)	Fréchet Inception Distance (FID)	Average Generation Time (s/image)
Original Stable Diffusion	6.23 ± 0.35	38.56 ± 2.14	4.8 ± 0.5
Stable Diffusion + LoRA	7.89 ± 0.28	22.34 ± 1.87	5.2 ± 0.6
Improvement Rate (%)	26.65	42.06	-8.33

As illustrated in Table 2, the optimized model achieved a 26.65% higher IS and a 42.06% lower FID than the original Stable Diffusion model. The elevated IS value demonstrates the enhanced innovative generation capabilities of the optimized model, thereby providing empirical support for Hypothesis H2, which proposes that the optimized model generates patterns with distinct innovative characteristics. Conversely, the reduced FID value indicates that the optimized model exhibits superior inheritance of traditional Shu embroidery styles. This lends support to Hypothesis H1, which posits that the optimized model generates patterns that conform to traditional Shu embroidery stylistic norms. Although the average generation time increased by 8.33%, this increment is deemed acceptable given the significant improvement in the balance between inheritance and innovation. These findings confirmed that LoRA fine-tuning effectively enhances the Stable Diffusion model's adaptability to Shu embroidery fan patterns and directly achieves the core objective of Objective 2: to optimize models to balance inheritance and innovation. Furthermore, they lay a solid foundation for the subsequent comprehensive evaluation of innovation performance (Objective 3), as the validated model's performance ensures the reliability of the patterns used in the subsequent evaluation.

Innovation Performance Evaluation Results of AI-Generated Shu Embroidery Fan Patterns

A comprehensive evaluation focusing on innovation performance was conducted on 40 patterns generated by the optimized model, integrating objective metrics and subjective assessment to validate the innovation level. Objective indicators accounted for 40% of the total score, while subjective evaluation accounted for 60%, with innovation assigned the highest weight in the subjective evaluation dimension. The detailed evaluation results are presented in Table 3.

Table 3. Comprehensive Evaluation Results of Generated Patterns (Full Score: 10)

Evaluation Dimension	Indicator	Score	Weight	Weighted Score
Objective Indicators (40%)	Inception Score (IS)	7.89	0.2	1.578
	Fréchet Inception Distance (FID)	8.26 (converted score, 10-point scale)	0.2	1.652
	Style Consistency	4.23 (5-point scale)	0.25	1.0575
Subjective Evaluation (60%)	Aesthetic Value	4.15 (5-point scale)	0.2	0.83
	Innovation	3.98 (5-point scale)	0.15	0.597
Total Score			1.0	5.7145 (10-point scale)

Note: The FID score is converted to a 10-point scale (the lower the original FID score, the higher the converted score).

As depicted in Table 3, the AI-generated patterns achieved a total weighted score of 5.7145 out of 10, indicating satisfactory performance in balancing inheritance and innovation. The high IS score (7.89) confirmed the high diversity and innovation of the generated patterns, further validating Hypothesis H2. Additionally, the stylistic consistency score of 4.23 out of 5 directly supports Hypothesis H1 by demonstrating the model's capacity to generate patterns that conform to traditional Shu embroidery styles. The aesthetic value score of 4.15 out of 5 indicates that the innovative elements embedded in the AI-generated patterns are highly recognized by both professionals and consumers, confirming their practical application value. Collectively, these results comprehensively validate Hypotheses H1 and H2, fulfill the requirements of Objective 3, which involves constructing a comprehensive evaluation system to validate application value. They also confirmed that the optimized model meets the modern design requirements of both inheritance and innovation. This evaluation outcome also logically connects with the subsequent color innovation analysis, as the overall validity of the generated patterns underscores the significance of exploring their color characteristics.

Analysis of AI-Driven Color Innovation for Generated Patterns

Color innovation constitutes a crucial dimension of the innovative design of Shu embroidery fan patterns. This section analyzes the color coordination of AI-generated patterns from an innovation perspective while adhering to traditional aesthetics. By comparing these patterns

with the traditional Shu embroidery color system, characterized by elegance, harmony, and rich gradations, the study validates the model’s capacity for color innovation. The analysis results are presented in Table 4.

Table 4. Color Matching Analysis of Generated Patterns

Color Type	Matching	Number Generated Patterns	of Proportion (%)	Consistency Traditional System (%)	with Color
Similar Matching	Color	18	45	92.3	
Complementary Color Matching		12	30	85.7	
Contrast Matching	Color	6	15	78.5	
Innovative Matching	Color	4	10	65.2	
Total		40	100	86.8	

As indicated in Table 4, similar color coordination accounted for 45% of the AI-generated patterns, with a 92.3% consistency with the traditional Shu embroidery color system. Complementary color coordination accounted for 30% of the patterns, with 85.7% consistency with the traditional color system. Notably, 10% of the patterns adopted innovative color coordination methods that are difficult to conceive through manual design, such as integrating contemporary popular colors within traditional color systems. Note that these innovative color schemes maintained a 65.2% consistency with the traditional color system while enriching the color expression of Shu embroidery patterns. The overall consistency between the AI-generated color schemes and the traditional color system reached 86.8%. This result directly validates Hypothesis H3, which proposes that the innovative color coordination of AI-generated patterns adheres to traditional Shu embroidery aesthetic principles.

Moreover, this finding addresses the research gap in the literature on insufficient color innovation in AI applications to Shu embroidery (identified in the literature review) and validates all three research hypotheses. It further realizes the goal of integrated pattern-color innovation outlined in the research objectives, thereby providing a logical closure to the study’s core research questions.

Discussion

Theoretical Implications of Generative AI-Driven Innovation in Intangible Cultural Heritage

Centered on generative AI-driven innovation in Shu embroidery fan patterns, this research has significant theoretical implications for the development of ICH.

Firstly, it addresses the identified research gap in the application of generative AI to Shu embroidery fan pattern design by clarifying the technical pathways and innovation mechanisms of AI in this specific domain. This extends the findings of Li et al. (2025), who focused on Miao embroidery patterns, by verifying the generalizability of AI-driven pattern innovation in another important ICH category. It also complements the research of Wang et al. (2025) on kite patterns, thereby enriching the theoretical system of AI-embroidery integration.

Secondly, it establishes a theoretical framework for the innovation of traditional Shu embroidery patterns using generative AI, defining the key stages (deconstruction, optimization, evaluation) and the technical criteria. This framework complements the AI-facilitated digital extraction framework proposed by the Hill Publishing Group (2025). This is achieved by adding model-optimization and comprehensive-evaluation modules, which provide a valuable reference for the innovative development of other traditional crafts.

Thirdly, it elucidates the mechanism through which AI achieves the unity of inheritance and innovation, an insight derived from the empirical validation of Hypotheses H1-H3, which aligns with the cultural gene theory proposed by Wu and Rich (2024). Consequently, this deepens the academic understanding of the interactive relationship between traditional culture and AI technology and provides empirical support for the digital inheritance of traditional crafts.

Collectively, these theoretical contributions logically stem from the study's core findings and address the theoretical gaps identified in the literature review.

Practical Implications of Generative AI Empowering Shu Embroidery Pattern Innovation

From a practical perspective, this research offers valuable guidance on applying generative AI to empower the innovative development of Shu embroidery. These practical implications directly correspond to the inheritance and development predicaments of Shu embroidery fan patterns identified in the introduction.

Firstly, the optimized model can rapidly generate a large volume of patterns that integrate traditional characteristics and innovative elements. This echoes the findings of Kang et al. (2025), who demonstrated the efficiency of diffusion models in traditional craft pattern generation. Furthermore, it addresses the practical pain point of designer scarcity in Shu embroidery by improving design efficiency and product innovation level, providing a technical solution for the innovative and industrialized development of Shu embroidery.

Secondly, the diverse thematic content and innovative color coordination of the AI-generated patterns cater to the personalized needs of contemporary consumers. This advancement extends Khamraeva's (2025) research on AI-generated textile design by focusing on the specific color aesthetic needs of Shu embroidery, thereby expanding market reach and enhancing the market competitiveness of Shu embroidery products. It also directly addresses the issue of traditional patterns failing to meet contemporary consumer demands.

Thirdly, the research findings can be incorporated into digital teaching systems for Shu embroidery, inspiring innovative thinking among learners and promoting the cultivation of professional talent in this field (Chen, 2025). This finding complements Shen's (2024) digital protection research by adding an innovative practice dimension to digital inheritance, thereby helping alleviate the scarcity of inheritors.

Fourthly, the AI-driven pattern innovation approach developed in this study can be replicated and applied to other forms of ICH. This is consistent with the radiating effect of AI empowerment proposed by Wang et al. (2025), exerting a positive impact on the broader ICH domain.

Limitations and Future Research Directions of Generative AI-Driven Pattern Innovation

This research is not without limitations, which also require future research directions. Firstly, the SEFPD dataset, comprising 200 samples, is relatively small, which may limit the model's ability to fully learn the stylistic characteristics of traditional Shu embroidery. Similar to the limitation noted by Li et al. (2025) in their Miao embroidery research, future research should expand the dataset scale to enhance the model's generalizability.

Subsequently, this study adopted only the Stable Diffusion model optimized via LoRA fine-tuning, without conducting comparative evaluations with other advanced generative AI models (e.g., MidJourney, DALL-E). Thus, future research should conduct comparative analyses to identify the most suitable model for Shu embroidery pattern innovation, thereby extending model-comparison research in AI-driven ICH innovation.

Additionally, the established evaluation system lacks indicators related to the practical applicability of the generated patterns, such as their suitability for fan surfaces and compatibility with embroidery techniques. This limitation is similar to the deficiency in practical evaluation indicators noted by Gündoğdu and Kahraman (2023) in their research on the evaluation of cultural creative products. Future research should refine the evaluation system by incorporating these practical indicators to enhance the real-world application value of the research findings.

Moreover, this study did not explore the integration of AI-generated patterns with actual embroidery production processes. Therefore, future work should apply the AI-generated patterns to real-world embroidery production to verify their practical utility and technical feasibility. This would bridge the gap between digital design and practical production, as noted in previous ICH innovation research, thereby further enhancing the practical significance of the research.

Conclusion

This research explores the value of generative AI models in deconstructing and innovatively designing traditional Shu embroidery fan patterns. It constructs a complete AI-driven research chain that covers deconstruction, optimization, and evaluation, centered on the core objective of balancing inheritance and innovation.

Based on the empirical results that validate Hypotheses H1-H3, the following key conclusions are drawn, which logically correspond to the research objectives and address the initial research problems:

- 1) The AI-facilitated deconstruction framework effectively extracts the pattern elements, compositional rules, and color characteristics of traditional Shu embroidery fans. It also successfully established the SEFPD dataset and laid a solid data foundation for AI-driven innovation, thereby accomplishing Objective 1 and addressing the data scarcity bottleneck in Shu embroidery AI research.
- 2) The optimized generative AI model (Stable Diffusion + LoRA) exhibits exceptional performance in innovative pattern generation. It produces high-quality, stylistically consistent, and highly innovative patterns that outperform the original model, thereby achieving Objective 2 and solving the problem of insufficient targeted model optimization for Shu embroidery.
- 3) The AI-generated patterns realize the organic unity of inheritance and innovation. They conform to traditional Shu embroidery aesthetics, supporting H1, while also demonstrating distinct innovative attributes in terms of elements, composition, and color, supporting H2 and H3. This fully meets the requirements of modern design, fulfilling Objective 3 and addressing the market adaptability issue posed by traditional patterns.
- 4) Generative AI technology serves as a core driver for the innovative development of Shu embroidery fan patterns. It provides a powerful technical tool for the inheritance and innovation of Shu embroidery while effectively addressing the challenges of inheritance and development faced by this traditional craft, as identified in the introduction.

Overall, this research confirms the feasibility and effectiveness of generative AI in driving the innovative design of traditional Shu embroidery fan patterns. It promotes the in-depth integration of Shu embroidery art with AI technology and advances the sustainable, innovative development of Shu embroidery. With the continuous evolution and advancement of generative AI technology, it is anticipated to exert an increasingly profound impact on the innovative inheritance of ICH, driving more traditional crafts to undergo innovation and industrial revitalization.

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