

Research on the Design Process of the Digital Regeneration of Miao Embroidery Patterns Under the Perspective of Human-machine Collaboration based on AIGC

Lu Lu*

Fine Arts Academy, Hunan Normal University, Changsha, 410000, China

**Corresponding author: Lu Lu.*

Abstract

The fast growth of digital technology and generative artificial intelligence (AIGC) has put the digital preservation and adaptation of traditional cultural resources under high-profile consideration. At present, most of the design of Miao embroidery cultural and creative products can be regarded as monotonous pattern applications, lack of innovative expression and poor conversion efficiency, and thus there is an urgent necessity to develop new design processes. The investigation of the methods of the contemporary adaptation of the traditional patterns supported by AI is a considerable value. The current research paper will discuss the digital revival of Miao embroidery forms and will attempt to develop a human-machine coordinated design system that would ensure the conservation of traditional culture on the one hand and modern adaptation on the other. On one side, this paper is cataloging traditional Miao embroidery patterns and isolating typical pattern elements and gathering consumer preferences related to pattern content, colors, and other aspects using a questionnaire survey. On the other side, when introducing generative AI tools, it creates new patterns based on semantic guidance and, together with human curation, it creates a human-machine cooperative design process consisting of: pattern feature extraction - user needs analysis - semantic-guided generation - human optimization and adjustment - design application validation. The findings have created a new AIGC-enabled human-machine partnership framework, and its practicality in visual representation and design implementation was confirmed by the cultural and creative product design practices, which have helped to promote the further integration of generative AI tools with the digitization of Miao embroidery patterns.

Keywords

AIGC, human-machine collaboration, digital regeneration, miao embroidery cultural and creative design

1. Introduction

Due to the fast growth of digital and artificial intelligence technologies, the Internet has opened up new ways of preserving and transmitting intangible cultural heritage (ICH). Simultaneously, the digital preservation and innovative diffusion of ICH has become an inevitable area of research in the discipline of design studies [1].

On one side, there are a number of present-day Miao embroidery culture and creativity goods that simply mix Miao ethnic factors along with contemporary goods in an over-simplified way to get innovative representation; on the other side, such goods are highly homogenous and the conversion efficiency of product designs is low and disconnected from the modern aesthetic [2].

The next generation of generative artificial intelligence applies text-based semantic processes to produce an enormous quantity of design proposals quickly, increasing design efficiency and decreasing design costs. Nevertheless, AIGC is an approach to the generation of digital content that includes interaction between humans and machines [3]. It is difficult to ensure that the proposals generated by AIGC are not only aesthetically pleasing but also culturally significant. The emphasis in this regard is thus on creating a human-machine collaborative design system that balances cultural heritage and design innovation, which is one of the research priorities in the sphere of AIGC-assisted design.

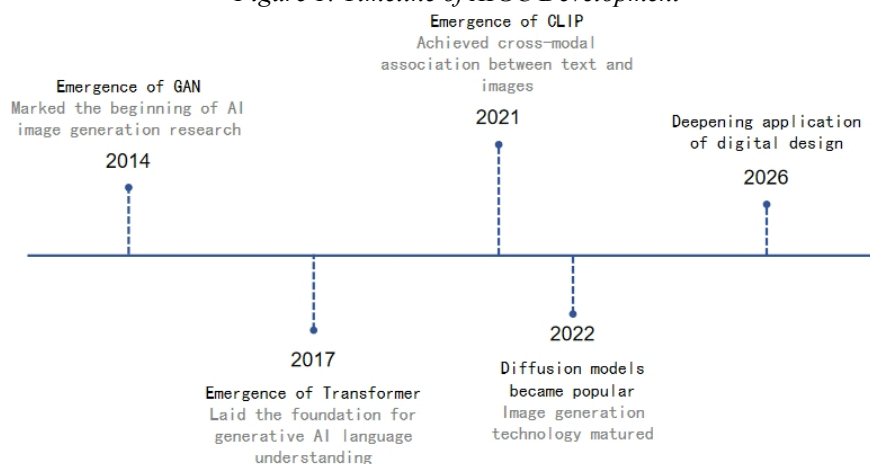
According to this, the research is aimed at the digital revival of Miao embroidery designs with an aim to investigate the human-machine collaboration in the design process which can be facilitated by the use of AIGC. It sets up a collaborative approach to design which includes the steps of pattern feature extraction, analysis of user requirements, semantics-based generation, human optimization and adjustment as well as validation of design application, thus offering a new paradigm of innovative design of Miao embroidery cultural and creative goods.

2. Overview of AIGC-Assisted Design

2.1 Current State of AIGC Research in Digital Design

The history of AIGC has been that of a technological progression starting with the Generative Adversarial Networks (GANs) that were developed in 2014 and culminating with the Diffusion Models that started gaining popularity in 2022 [4]. Existing AIGC models can generate good quality images and will eventually move towards generative creative models (figure 1).

Figure 1: Timeline of AIGC Development



The change has helped AIGC to make pioneering advances in the sphere of artistic production. The use of artificial intelligence technologies will transform the sphere of artistic creation and will lead to the emergence of three basic types of artistic production: autonomous creation by humans, autonomous works of art generated by artificial intelligence, and the creation of art through collaboration between humans and machines [5]. However, as AIGC also expands its presence into design, the current literature on AIGC and digital design has mostly been devoted to commercial images or image synthesis in general. The systematic study of how to use such a mechanism in the regeneration of traditional intangible cultural heritage patterns, which are highly culturally authentic, is still very narrow.

2.2 Overview of Human-AI Collaborative Workflows Based on Generative AIGC

Human-AI cooperation in AIGC-assisted design processes is a process that has over time developed into a more or less constant functioning system. The designers give semantic direction to the AI according to the design objectives, and the AI produces and expands design proposals. The proposals are subsequently filtered and modified by the designers, and finally produce a solution that will satisfy the design objectives. At this moment, generative AI cannot be considered as an autonomous creator because generative image art still depends upon the judgment, correction, refinement, and interpretation of humans [6]. Although existing AIGC is able to generate high-quality images, the outputted results are highly random, and human designers need to guide and select.

Although AIGC-based design has already developed a fairly mature human-machine collaboration flow, when it comes to the realm of traditional cultural design, especially in the process of digital reconstruction of Miao embroidery motifs, design proposals should take into account all cultural connotations, visual aspects, and current design demands.

3. Design Characteristics and Issues of the Digital Regeneration of Miao Embroidery Patterns Analyzed

3.1 Extraction of Design Characteristics from Miao Embroidery Patterns

It is expected that in order to make the design suggestions developed by AIGC balanced in terms of cultural importance and aesthetic value, it must select characteristics of Miao embroidery motifs according to what is depicted in them, color combinations, and composition.

Miao embroidery patterns are mostly inspired by nature and ethnic culture and have a particular auspicious significance, e.g., the fish motif, which is a figurative depiction of an object, denotes fertility and prosperity. Rich and brilliant hues are used in Miao embroidery, and a combination of vermilion, peach pink, navy blue, and black is often used to highlight the decorative as well as cultural value of the colors. The compositions may be divided into four groups: perfectly symmetrical, imperfectly symmetrical, radial-curvilinear, and hybrid. Nevertheless, the composition of Miao embroidery designs is practically altered depending on the form and dimensions of the embroidered piece. Such flexible composition requires particular care to be taken during the AIGC generation stage so that the ethnic purity of the patterns cannot be compromised due to the divergence of the essential compositional features of Miao embroidery.

3.2 Analysis of Challenges in the Digital Transformation of Miao Embroidery Patterns

The new developments in digital technology over the past few years have led to the innovative spread of Miao embroidery designs, but their digitalization as a part of contemporary culture and creativity products remains associated with various obstacles.

3.2.1 Difficulties in Digital Adaptation

Many researchers and projects have examined novel methods to the digitalization of conventional designs, but most of them concern the visual design of the designs and very little attention is paid on the loss of textural quality and stitching logic in the digitization process of Miao embroidery patterns, which are of great cultural importance [7, 8]. Therefore, the question of what to do to ensure digital expression without losing the traditional cultural features is the key problem in the digital revival of Miao embroidery patterns.

3.2.2 Low Efficiency in Transforming Traditional Designs

Other scholars have also investigated other forms of redesigning and implementing intangible cultural heritage (ICH) through the analysis of the connection between ICH and cultural and creative products [9]. However, the existing innovative frameworks of conversion of Miao embroidery patterns to cultural and creative products are highly dependent on human expertise, which leads to long design periods and, to a certain degree, restricts the effectiveness of the innovations and the pace of the products' development. Introduction of AIGC is an attempt to create an extremely efficient mechanism of transformation based on semantic processing as a way of improving design efficiency.

3.2.3 Lack of Modern Aesthetic Adaptation

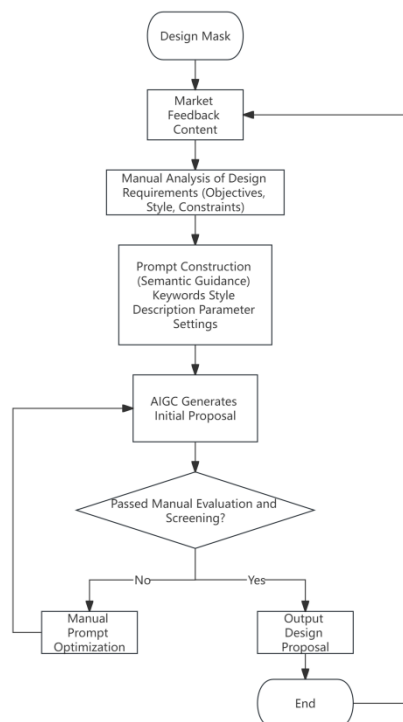
The future of ethnic minority products in the modern market will depend significantly not only on the cultural requirements, consumer behavior, aesthetic preferences and appreciation patterns of modern society but also on the competitiveness and sustainability of the ethnic minority products themselves [10]. The conflict of aesthetics is present between the new tendencies of the cultural and creative market, i.e. The preference for minimalism, low saturation, and functionality, and the natural features of Miao embroidery, such as intricacy, high saturation, and ornamentality. It is thus a major issue in the contemporary aesthetic adaptation of Miao embroidery to achieve this balance in these different aesthetics.

4. Development of an AIGC-Based Human-Machine Coordination Design Process for Miao Embroidery Patterns

4.1 Development of a User-Feedback-Driven Human-Machine Collaborative Design Model

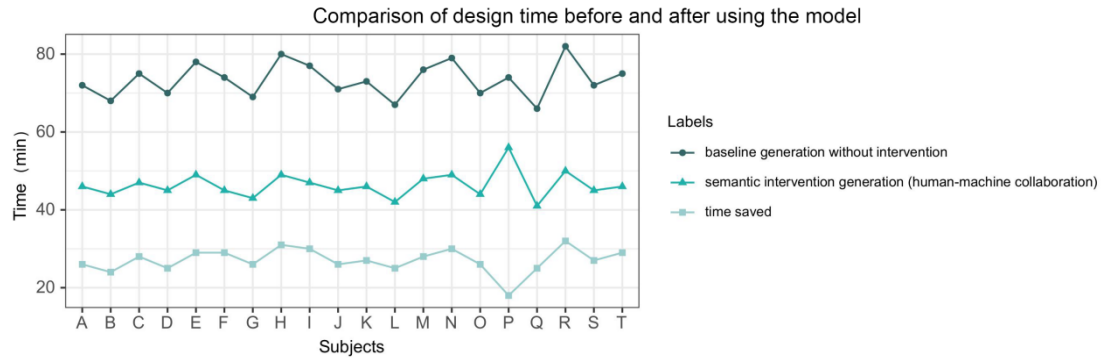
The research created a human-machine cooperative design model that is driven by user feedback (refer to Figure 2). With the use of AIGC-based design software, a collaboration design system was introduced involving the following steps: market feedback- semantic input (prompt)- AIGC output- result filtering- manual optimization- feedback iteration wherein the critical step is putting the role of the designer in making decisions at the center. In order to reduce the discrepancies between the ethnic culture core and what is generated by the randomness of AIGC content, designers apply cultural encoding in accordance with the feature library derived out of Miao embroidery as previously stated to build prompts and cultural decoding in accordance with aesthetic judgment when AIGC design proposals are made. The model is more efficient than the conventional design processes in terms of design efficiency of Miao embroidery patterns during their digitization.

Figure 2: A User-Feedback-Driven Model for Human-Machine Collaborative Design



The study chose 20 design students who have design skills (n=20) and adopted a within-group controlled experiment to compare the design efficiency of traditional design and design that will be informed by this model (refer to Figure 3). The SUS survey was performed after the experiment (refer to Table 1).

Figure 3: Comparison of Design Time Before and After Using This Model



Following the implementation of the human-machine collaborative design model that is recommended in this research, the mean design time of the experimental group was found to be 37.7 percent higher than that of the control group ($p < 0.01$) and the average design time decreased by 27.5 minutes.

Table 1: Average Scores from the SUS System Usability Survey

Question No.	Content	Average Score
Q1	Willing to use this design process frequently	4.4
Q2	The using process is relatively complex	1.9
Q3	The process is easy to operate	4.5
Q4	Requires professional support	2.0
Q5	The various stages are well-integrated	4.3
Q6	There are many inconsistencies	1.8
Q7	Most people can master it easily	4.4
Q8	The process is cumbersome	2.1
Q9	I feel confident using it	4.5
Q10	The learning curve is steep	2.0
Total	Average Final SUS Usability Score	81.7

The SUS average score was 81.7, meeting the benchmark for excellent usability.

Designers tend to take a lot of time during the process of concept generation during traditional design processes. The change in the position of AI as an intern to being a partner implies that designers are required to learn successful collaboration with AI. The combination of the intuition and professional judgment of designers and the data-driven decision-making capability of AI may be able to maximize the results of designs [11]. This model presents AIGC-assisted tools to come up with first proposals, enabling the designers to eliminate unnecessary repetitive labor and rather concentrate on the end assessment and choice. This change in the process improved the efficiency of the design conversion rate by 37.7 percent ($p < 0.01$). The outcome is similar to what has been reported in recent studies about the efficiency of AIGC collaboration systems, as they have been found to be very helpful in increasing work efficiency [12].

4.2 A Semantically-Guided Human-Machine Collaborative Generation Intervention Mechanism

The concept of generation quality is very much related to semantic guidance in AIGC. By implementing a semantic-guided human-machine interaction to produce the generation process intervention mechanism, it takes the form of a response to user feedback on current trends in aesthetics, including but not limited to minimalist and low-saturation, which are transformed into particular style prompts that can be utilized by AIGC generation models. Parameters are employed to limit the produced content, and allow optimizing the initial prompts in order to match the authenticity of Miao embroidery patterns with the contemporary aesthetic taste.

The experiment included 30 participants. First of all, a survey on Miao embroidery pattern preferences among the 30 participants was carried out to be analyzed (see Table 2). The users showed clear preference for the minimalist and low saturation as it was highly frequent.

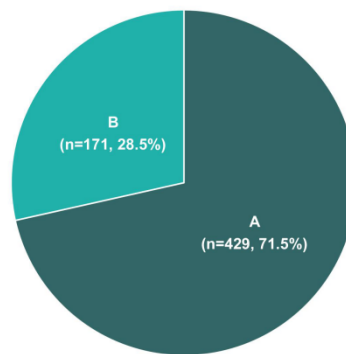
Table 2: Frequency Table of User Preferences for Miao Embroidery Patterns

Rank	Preferred Term	Frequency	Relative Percentage (%)
1	Minimalist Style	28	20.3
2	Low Saturation	25	18.1
3	Symmetrical Composition	15	10.9
4	Floral Patterns	13	9.4
5	White space	12	8.7
6	Modern Aesthetic	10	7.2
7	Flat Design	9	6.5
8	Butterfly Patterns	8	5.8
9	Clean Lines	7	5.1
10	Fresh Color Palette	5	3.6
11	Traditional Chinese Style	3	2.2
12	Geometric Patterns	3	2.2

Following manual optimization of the prompts to indicate style parameters of the AIGC generation model, Group A produced illustrations of the Miao embroidery styles with these restrictions in mind, whereas Group B applied the default prompts. Thereafter, a double-blind experiment was carried out to evaluate the preference of the participants (Figure 4).

Figure 4: Preference distribution based on 600 blind test evaluations conducted by 30 participants

Preference proportions (600 blind tests, 30 subjects)



Miao embroidery patterns created in the absence of this mechanism have a tendency to maintain the intricate, saturated, and decorative qualities that are commonly associated with traditional Miao embroidery. Human beings have an extremely sophisticated emotional system and a distinct sense of aesthetics, whereas AIGC has no way of precisely depicting and comprehending the delicate emotions of customers and their aesthetic tastes [13]. This mechanism, however, analyzes the user preferences and uses semantic guidance provided by humans so as to recreate design suggestions and makes Miao embroidery designs more consistent with the user preferences on minimalism, low saturation, and functionality of colors, composition, and pattern combinations. Out of 30 participants, 71.5 percent indicated a preference for Group A (the restricted group) ($p < 0.01$).

As of now, generative AI is only an instrument to help people with their work and daily routine [14]. Designers can take on a dominant position during the entire design process by giving particular semantic directions to users through their feedback, which will effectively limit the generated material to ensure that Miao embroidery patterns are more consistent with contemporary tastes.

5. Application of AIGC-Assisted Design of Cultural and Creative Products Featuring Miao Embroidery Patterns

5.1 Practical Implementation of Regenerative Design for Themed Miao Embroidery Cultural and Creative Products

A practical application of the proposed human-machine collaborative design model in the current paper will be to implement regenerative design in practice in relation to the themed Miao embroidery cultural and creative goods.

To begin with, the typical Miao embroidery designs are created involving butterfly and flower designs. By adding the outcomes of a user preference survey to this, conversion of user preference terms is performed, e.g., minimalist style, low saturation, symmetrical composition into semantic constraints that can be used by Midjourney to create prompts (refer Table 3).

Table 3: Midjourney Pattern Generation Positive Prompt Control Parameters Table

Control Dimension	Design Requirements	Prompt
Cultural Elements	Preserve the ethnic cultural characteristics of Miao embroidery	Miao embroidery pattern, butterfly motif, floral ornament, traditional ethnic pattern
Composition Control	Modernize traditional pattern structures while maintaining visual order	geometric symmetry, balanced composition, decorative pattern
Color Control	Meet users' preference for low-saturation aesthetics	Morandi color palette, low saturation, soft colors, muted tones
Style Control	Achieve a blend of ethnic style and modern aesthetics	Modern Chinese style, contemporary design, cultural creative design
Product Adaptation (Pillow)	Aligns with the square display structure of pillows	Square cushion pattern, central composition, balanced visual hierarchy
Product Adaptation (Scarf)	Aligns with the characteristics of continuous patterns on scarves	seamless pattern, border decoration, repeating floral layout

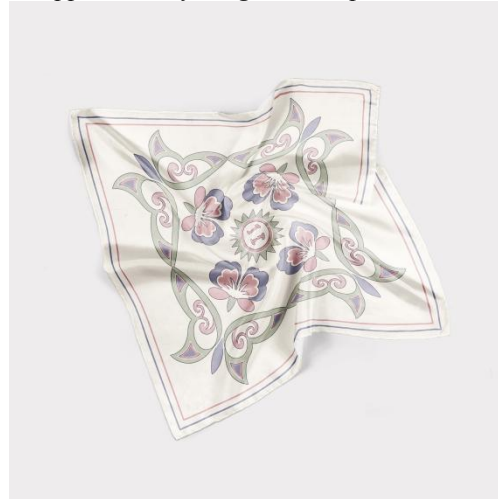
Prompt adapts its operations to different cultural and creative products so that the created patterns would be very suitable to each product.

Meanwhile, through the use of negative prompts to manage variables like color and image quality, increased controllability of the generated results is obtained (Table 4).

Table 4: Negative Prompt Control Parameters for Midjourney Pattern Generation

Control Objective	Negative Prompt	Filtering Effect
Color Control	high saturation, over saturated color	Avoid generating overly vivid colors that deviate from aesthetic needs.
Image Quality Control	blur, noisy background, low quality	Reduce blur and noise, improve pattern clarity.
Composition Control	asymmetrical composition, chaotic layout	Avoid chaotic structure and disorder in the pattern.
Style Control	photo realistic, 3D rendering	Avoid generating photorealistic images.
Detail Control	excessive details, distorted pattern	Prevent excessive complexity of pattern details.

The process of pattern generation is performed in Midjourney. Once the generation is done, manual screening is done to make sure that the generated patterns have both cultural value and a contemporary aesthetic sense (refer to Figure 5). In this case, the creation of scarf design patterns is used as an example. The last generated Miao embroidery patterns are used on cultural and creative products like scarves (see Figure 6) to conclude the design practice.

Figure 5: AIGC-generated pattern*Figure 6: Application of the generated pattern on a silk scarf*

5.2 Design Scheme and Efficiency Analysis

5.2.1 Pattern Generation Efficiency

Pattern generation in the design practice was done by AIGC, and semantic organization and aesthetic screening by designers, which minimized repetitive drafting and saved time. The mechanism of human-machine cooperative generative intervention grounded on semantic direction guaranteed that cultural aspects, composition, color, and style of patterns were limited during the Prompt development process, which made the process of generating results more controllable and took less time. Subsequently, the introduction of the suggested model improved the general efficiency of the design practice.

5.2.2 Visual Style Consistency

AIGC outputs are quite random; hence, they need restrictions in Prompt development to enhance the accuracy of the results. Within the design process, positive prompts like Miao embroidery patterns, geometric symmetry, and Morandi color palette were used to limit the style, composition, and color of the produced patterns. At the same time, negative prompts like blur, noisy background, and high saturation were used to regulate the quality of the produced patterns and minimize the presence of patterns with high-saturation noise. The resulting patterns had the same qualities that could be achieved through the restriction of Prompts in various dimensions, including low-saturation colors and short lines, thus creating a visual impression that combines a modern sense of beauty with traditional aesthetic characteristics of ethnic style.

5.2.3 Cultural Recognizability

At Prompt construction, the descriptive attributes of Miao embroidery patterns, i.e., the Miao embroidery pattern, butterfly motif, floral ornament, traditional ethnic pattern, were used to make sure that the results produced had kept their ethnic quality of the Miao embroidery. A user perception analysis was done using twenty subjects ($n = 20$) to determine how well the generated patterns performed in terms of cultural recognizability. The outcome revealed that the collective estimation of the ethnic cultural expression of the design schemes was high (see Table 5), where more than 90% of participants rated themselves as satisfied. Manual refinement process also enhanced the cultural recognizability of patterns, allowing the final design results to not only reflect the ethnic uniqueness of Miao embroidery but also meet the aesthetic demands of modern consumers.

Table 5: Statistics of User Cognitive Evaluation Results

Indicator	Average Score	Satisfaction Rate (score ≥ 4)
Cultural Recognition	4.45	90%
Retention of Traditional Elements	4.35	90%
Integration of Modern Aesthetics	4.30	95%

6. Conclusion

6.1 Research Summary

This paper investigates a human-machine cooperative design strategy which is supported by AIGC. With the help of user responses, a design framework of the form “market feedback - semantic input (Prompt) - AIGC generation - result screening - manual optimization - feedback iteration” is developed. The validity of the model in enhancing the efficiency of designs and conforming them to current standards of aesthetic taste is tested by experiment. In design practice, the model is practically feasible, hence providing a new direction towards strengthening the intangible cultural heritage (ICH) creative design using AIGC.

6.2 Research Limitations

There are a few limitations to this study. To begin with, the sample size of the user survey is small, and the results of the research should be confirmed by a bigger number of respondents. Also, the paper mainly uses Midjourney as the means of generating patterns, and the selected AI tools used have their constraints. Besides, the design practice has concentrated more on cultural and creative goods and has not been applied to other areas of life like fashion design.

References

- [1] Yan Wang, Yishan Xue, Xi Zhang & Yuxin Li. (2024). Innovations in the Protection and Inheritance Paths of Intangible Cultural Heritage in the Digital Age. *News World*, (3), 6-8. <https://doi.org/10.19497/j.cnki.1005-5932.2024.03.022>.
- [2] Yingjie Xu. (2021). Research on Ethnic Cultural and Creative Products Promoting Targeted Poverty Alleviation and Rural Revitalization: A Case Study of Miao Embroidery in Xiangxi. *Minzu Forum*, (3), 69-77. <https://doi.org/10.19683/j.cnki.mzlt.2021.03.009>.
- [3] Baiyang Li, Yun Bai, Xini Zhan, & Gang Li. (2023). The Technical Features and Aromorphosis of Artificial Intelligence Generated Content (AIGC). *Documentation, Information & Knowledge*, 40 (1), 66-74. <https://doi.org/10.13366/j.dik.2023.01.066>.
- [4] Yihan Cao, Siyu Li, Yixin Liu, Zhiling Yan, Yutong Dai, Philip Yu, & Lichao Sun. (2025). A Survey of AI-Generated Content (AIGC). *ACM Computing Surveys*, 57 (5), 1-38. <https://doi.org/10.1145/3704262>.
- [5] Wanying Yu. (2024). Analysis of the Transformative Impact of Artificial Intelligence on Artistic Creation. *Journal of Nanjing University of the Arts (Fine Arts & Design)*, (1), 190-194.

- [6] Yongjie Gao & Xin Lv. (2023). Evolution of Generative AI Technology and Paradigm Innovation in Image Art Production. *Modern Communication (Journal of Communication University of China)*, 45 (9), 159-168. <https://doi.org/10.19997/j.cnki.xdcb.2023.09.011>.
- [7] Yukang Hou, Jian Lv, Xiang Liu, Tao Hu, & Zeyu Zhao. (2020). Innovative method of ethnic pattern based on neural style transfer network. *Journal of Graphics*, 41 (4), 606-613.
- [8] Yunchun Chen, Tie Ji, Jian Peng, & Bin Wang. (2023). Intelligent design path of Huayao cross-stitch patterns based on style characteristics. *Journal of Silk*, 60 (9), 112-119.
- [9] Qing Bai, Yuxiang Ren. (2023). Cultural and Creative Product Design Based on Intangible Cultural Heritage Culture. *Packaging Engineering*, 44 (18), 351-353+384. <https://doi.org/10.19554/j.cnki.1001-3563.2023.18.041>.
- [10] Ruijuan Xing, Wendong Wang. (2021). Inheritance and Development of Guizhou Minority Folk Crafts under the Strategy of Rural Revitalization. *Guizhou Ethnic Studies*, 42 (3), 124-132. <https://doi.org/10.13965/j.cnki.gzmzyj10026959.2021.03.016>.
- [11] Yingqing Xu, Qinyi Zhou, Jie Deng, Yu Zhang, & Xinyi Fu. (2024). Application and Development of Artificial Intelligence in Design Industry. *Packaging Engineering*, 45 (8), 1-10. <https://doi.org/10.19554/j.cnki.1001-3563.2024.08.001>.
- [12] Li, C., Ye, Z., Wen, W., Li, L., & Shao, J. (2025). Beyond Photorealism: An AIGC-Powered Framework for Stylized and Gamified Cultural Heritage Revitalization. *Buildings*, 15 (20), 3782. <https://doi.org/10.3390/buildings15203782>.
- [13] Dongqi Jiu. (2024). Exploring the Integration Path of AIGC and Visual Communication Design in the Context of Human-Machine Collaboration. *Media & Art Studies*, (1), 139-146.
- [14] Ruizhi Zhao & Hui Li. (2023). Research on the Value, Dilemmas, and Countermeasures of AI Painting for the Creative Side in the Context of AIGC. *Beijing Culture Creativity*, (5), 42-47.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest.

Acknowledgment

This paper is an output of the science project.

Copyrights

Copyright for this article is retained by the author (s), with first publication rights granted to the journal. This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/4.0/>).