



Application of Generative Artificial Intelligence in the Design of Traditional Miao Clothing as Intangible Cultural Heritage

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Abstract. Recently, generative artificial intelligence (AI) has brought significant transformations to the field of design, providing the fashion industry with a variety of efficient new design methods and areas, and also creating new opportunities for the digital innovation of traditional culture. Under the impact of globalisation and digitalisation, the inheritance of intangible cultural heritage is facing unprecedented challenges. Taking Miao ethnic costumes as an example, their intricate embroidery patterns and unique colour palettes carry millennia of memories, but they are gradually losing their cultural space under the pressure of modern industrial production. Faced with the challenge of the endangered traditional costumes of the Miao ethnic group, applying generative AI to their pattern design not only helps to protect and inherit intangible cultural heritage but also promotes its continuation and re-creation in modern society. The purpose of this study is to explore the application of generative AI in the design of intangible traditional Miao clothing. To achieve this goal, the study adopts a variety of research methods, combining design practice with cultural research, to examine the innovative application of generative artificial intelligence (GAN) in the pattern design of traditional Miao ethnic costumes and its cultural adaptability. The main research methods include the training of GAN models and pattern generation. Semi-structured interviews, co-design, and comparative analysis are used to evaluate cultural integrity. The findings suggest that generative AI can serve as an effective tool in the design of traditional Miao patterns, enabling outputs that are more aligned with cultural semantics and social contexts, thus contributing to both the preservation and innovative expression of this heritage. Theoretically, the study extends the application boundary of computational creativity theory in the realm of culturally sustainable design. This framework is applied systematically for the first time to the AI-driven generation of Miao traditional patterns, offering a comparative analysis between AI-generated and manually designed motifs to examine cultural integrity. On a practical level, this research proposes a concrete pathway for applying generative AI in traditional Miao fashion design, providing new insights into the integration of AI and cultural heritage. It offers feasible strategies for the sustainable transmission and creative revitalisation of intangible cultural heritage in the digital era.

Keywords: Generative Adversarial Networks (GAN), Artificial Intelligence, Fashion Design, Miao Ethnic Minority

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1 Introduction

In the present day, the research and application fields of artificial intelligence (AI) have expanded significantly, covering a variety of disciplines. In particular, AI has played a significant role in the design sector. Driven by AI-powered technological innovation, the fashion industry is undergoing a revolutionary change [1][2][3]. Among these technologies, generative AI has attracted increasing attention from both academia and industry due to its ability to produce diverse and highly customised outputs [4]. Fashion designers can optimise designs and improve efficiency by integrating fashion knowledge and generative AI technology in the redesign process.

Research into the application of AI in fashion design can be traced back to the early 2000s, when evolutionary algorithms such as Genetic Algorithms (GA) and Interactive Genetic Algorithms (IGA) were primarily used to optimise existing designs and support creative ideation [5][6][7]. More recently, the development of generative models such as Generative Adversarial Networks (GANs) and Variational Autoencoders (VAEs) has significantly enhanced image generation capabilities. In particular, GANs—by leveraging the adversarial process between generators and discriminators—can create images with near-photorealistic quality, facilitating the automated and high-quality generation of fashion visuals [8] [9] [10].

At the same time, with the rapid development of technology and economy, the process of urbanisation is accelerating rapidly. The fast pace of modern urban life has had a significant impact on the traditional clothing culture and lifestyle of the Miao ethnic group. Data shows that the traditional culture of the Miao people is facing the severe challenge of extinction and cultural erosion [11].

As a form of Chinese national intangible cultural heritage, Miao traditional clothing embodies deep historical memory and rich cultural meaning. Its motifs encompass themes of totem worship and secular emotion, while its vibrant colour schemes express symbolic interpretations of life and nature [12][13]. Despite their cultural value, Miao patterns have largely relied on manual design, which often suffers from a lack of innovation and cultural understanding. As a result, these designs struggle to resonate with the general public, leading to a gradual marginalisation of Miao clothing in contemporary fashion. Even though some motifs have drawn short-lived attention from international fashion houses—such as Hermès' incorporation of Miao elements at Paris Fashion Week [14]—the challenges posed by modern lifestyles and mainstream aesthetics continue to threaten their sustainable inheritance.

Against this backdrop, applying generative AI to the preservation and redesign of Miao traditional patterns emerges as a compelling direction. Cultural heritage is not a static object, but rather a dynamic process that is continually constructed and reconstructed through social practice. It represents a selective interpretation and reproduction of the past within specific contexts [15]. Thus, cultural preservation involves not only safeguarding traditions but also revitalising and reinterpreting them in contemporary forms. As UNESCO emphasises, intangible cultural heritage is constantly recreated through transmission and community practice, and it serves relevant social functions [16]. The integration of generative AI does not aim to replace traditional culture but to

participate in it through a collaborative, negotiated process—connecting heritage bearers, designers, and consumers to co-create contemporary expressions of Miao clothing. This approach enhances the cultural appeal of Miao attire within modern society while offering a novel technological pathway for the continuity and innovation of intangible heritage.

At present, fashion-related AI research focuses mainly on forecasting fashion trends, assisting creative design, and analysing market tendencies [17][18]. For example, a review of over 580 AI-related studies in fashion identified 22 key application areas, including apparel design, fabric analysis, and trend prediction—but few have addressed the use of AI in the design of traditional clothing [17].

Although research on the protection of intangible cultural heritage has increased in recent years, comprehensive studies on specific minority garments—especially Miao traditional clothing—remain scarce. In particular, there is a lack of in-depth inquiry into how AI can support the transmission and innovation of such traditions through design-led intervention.

While some studies have reviewed the technical applications of AI in intangible heritage (e.g., data collection, intelligent classification, virtual restoration), they tend to overlook the dual role AI may play—providing both opportunities and risks. For instance, while Ma et al. highlight the potential of AI in enhancing the efficiency and precision of heritage preservation, they do not address the possible cultural homogenisation that may arise when AI intervenes in traditional clothing design. Moreover, there remains a notable gap in empirical research focused on the digital preservation and creative reinterpretation of traditional Miao dress.

Though some scholars have explored the relationship between AI and traditional Chinese clothing—such as Liu (2024), who investigated the potential of AI in facilitating pattern generation and style transfer to expand the reach of traditional garments on digital platforms—such studies primarily focus on Han clothing and lack case studies related to ethnic minority traditions, particularly the Miao.

To bridge this research gap, the present study investigates the effectiveness of generative models in the design of intangible traditional Miao clothing.

We attempt to address the following three research questions in this study:

RQ1. Within the context of intangible cultural heritage preservation, what does cultural protection truly mean, and how can AI facilitate the transmission and revitalisation of traditional Miao clothing?

RQ2. As digital technologies—and AI in particular—intervene in the design of traditional Miao clothing, how can digitalisation simultaneously support and threaten cultural preservation?

RQ3. As an innovative approach responding to cultural needs, how can AI move beyond the role of a design tool to become an effective agent in the revival and contemporary expression of Miao culture?

2 Theory Underpinning

This study draws on Margaret Boden's (2004) Computational Creativity Theory [19]. Boden proposed that creativity is not an exclusively human trait but can also be simulated and generated through computational systems. She categorised creativity into three types: combinational creativity, exploratory creativity, and transformational creativity. Combinational creativity involves combining existing ideas or elements in new ways to produce results that appear novel but are based on existing logic. Exploratory creativity entails a deep exploration within a given style or rule space, discovering previously unknown possibilities by altering parameters or pathways. Transformational creativity is more radical, as it breaks through existing styles by altering or expanding the logical space, creating new design languages, ways of thinking, and systems [19].

Among these, combinational and exploratory creativity are particularly relevant to the performance of GAN models in the generation of fashion patterns. On the one hand, AI learns traditional Miao pattern data through combinatorial creativity, and recombines existing traditional Miao design elements in a completely new arrangement to generate seemingly novel patterns based on the rules of the original Miao elements. On the other hand, exploratory creativity can also be used for deep exploration, bringing about new possibilities for the colour, arrangement, and hierarchy of patterns, and generating new forms of patterns within the traditional pattern systems.

This manifestation of 'computational creativity' makes AI not merely a tool to aid design, but as a potential co-creator capable of producing new patterns with both cultural continuity and visual novelty in the rule-based system of traditional Miao patterns. Specifically, this yields several positive impacts: Firstly, it enhances the visual diversity of traditional Miao patterns, avoiding the monotony and repetition of pattern expression; Secondly, by innovating cultural symbol designs, AI-generated outcomes can better attract the attention of the younger generations and the global market, which can enhance the dissemination and influence of Miao clothing in contemporary society; Finally, this fusion of tradition and innovation provides a new pathway for the inheritance of Miao culture, helping to sustain the dissemination and recognition of intangible cultural heritage.

Computational Creativity Theory provides an essential theoretical foundation for this study. By mapping the behaviour of GANs in pattern generation to the categories of combinational and exploratory creativity, this theory allows us to infer that AI not only can imitate traditional patterns but also has the potential to deeply explore new possibilities within the rule space of Miao clothing design that have not yet been activated. This capability contributes to the continuous innovation and dissemination of traditional culture within contemporary contexts. In other words, Computational Creativity Theory not only explains the mechanism of AI-driven design but also reinforces the argument of this study that AI can serve as an active agent of cultural innovation.

2.1 Generative Adversarial Network (GAN) AI Model

For traditional Miao clothing design, there is a higher demand for both pattern design and the generation of realistic images. Generative Adversarial Networks (GANs) not

only generate high-quality patterns but also adapt well to the complex cultural and aesthetic characteristics of Miao clothing, offering greater flexibility and effectiveness in design. GANs are an emerging semi-supervised and unsupervised learning technology that has received extensive attention in AI-based clothing design research. They achieve this goal by implicitly modelling the distribution of high-dimensional data. GANs were proposed in 2014 [8], and are characterised by training a pair of neural networks. A common metaphor for visual data is to regard one network as an art forger, namely the generator, and another network as an art appraiser, namely the discriminator [20]. Subsequently, various derivative models based on GANs have emerged, making image editing easier. In fashion design research, GANs have been used to create graphics printed on clothing [18] [21].

The adversarial training mechanism of GANs gives them significant advantages in dealing with complex image generation tasks. The generator continuously optimises the generated results through competitive learning with the discriminator, thus enabling it to adapt to the distinctive pattern style characteristics of the Miao ethnic group. At the same time, this mechanism also ensures that while guaranteeing the authenticity of the cultural inheritance of Miao ethnic patterns, it innovatively combines with modern design. Furthermore, compared with other generative models such as VAEs, GANs can generate finer and more detailed images. In terms of flexibility, GAN models are more adaptable to different design requirements: by adjusting the input of the generator and the model architecture, different styles of Miao clothing patterns can be generated to meet different design needs.

2.2 The Dual Role of Generative AI in the Protection of Miao Intangible Cultural Heritage

This study further explores the dual role of digital technologies in the protection of intangible cultural heritage, especially in the inheritance and innovation of traditional Miao clothing. As an emerging digital tool, generative AI has shown advantages in providing creative design solutions and improving efficiency, but it also brings challenges regarding how to express and convey cultural connotations. Therefore, this study explores the impact of digitalisation on the protection of Miao ethnic clothing culture from both positive and negative perspectives.

On the positive side, AI and digital modelling technologies make it possible to systematically collect and reproduce traditional Miao patterns, enabling more accurate and efficient preservation of cultural materials and breaking away from the limitations of relying on manual recording [22]. In addition, the patterns generated by AI can be innovated in design by combining contemporary aesthetic demands with the recreation of traditional patterns of the Miao ethnic group. The multi-sensory digital interaction form enhances the interest and experiential dissemination of traditional clothing among the younger generation, injecting new vitality into the inheritance of intangible cultural heritage [23].

However, the application of digital technologies also brings potential cultural threats. First, AI-generated images produced without a deep understanding of ethnic culture may result in misuse or alienation of totemic symbols and traditional patterns

[22]. Second, the standardisation of samples during algorithm training may weaken local characteristics and individual variations in Miao patterns, leading to a homogenisation of cultural expression. At the same time, uneven access to technology and limited digital infrastructure in some ethnic minority areas could exacerbate the marginalisation of their cultural voice [23].

This paper argues that digital technologies have brought significant achievements in the inheritance, dissemination, and innovation of intangible cultural heritage, provided that respect for culture is ensured and that the cultural regions and participants' agency are strengthened. On this basis, the protective role of digital technologies still outweighs their potential threats.

3 Methodology

This study attempts to integrate design practice with cultural research. On one hand, it conducts experimental generation of Miao patterns using Generative Adversarial Networks (GANs) to explore the specific applications and innovative potential of generative AI in traditional pattern design. On the other hand, it adopts cultural research methods—such as semiotic analysis and community interviews—to uncover the cultural meanings and contextual foundations behind the patterns, aiming to balance the aesthetic quality of the generated results with their cultural appropriateness.

3.1 GAN Model

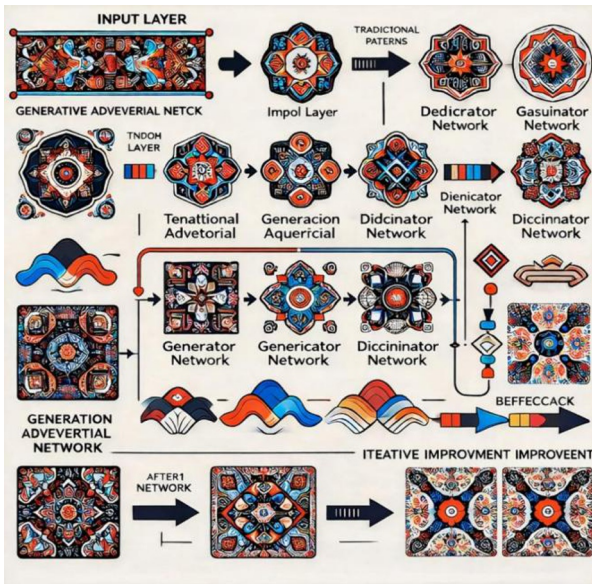


Fig. 1. Workflow of the GAN Model

Figure 1 visually describes the application process based on the GAN model learning method. The process is as follows:

- **Input Layer**

Traditional Miao clothing patterns, colours, and cultural data are collected to provide foundational training data for the AI model.

- **Generator Network**

Based on the input data and random noise inputs, the generator creates new Miao clothing patterns that retain cultural authenticity while integrating contemporary aesthetics.

- **Discriminator Network**

This component evaluates the cultural authenticity of the generated patterns, filters unsuitable outputs, and provides feedback to improve the generation quality.

- **Feedback Loop**

Through continuous adversarial interaction between the generator and discriminator, the system progressively optimises both the realism and creativity of the generated patterns.

- **Final Output**

The resulting Miao clothing patterns closely resemble traditional aesthetics, meet the needs of cultural preservation, and incorporate modern design elements in a creative way. As illustrated in Figure 2, the GAN-based workflow demonstrates how traditional Miao patterns are integrated into contemporary skirt design.

Although GAN models demonstrate powerful capabilities in pattern generation, relying solely on technology still presents limitations when applied to the specific cultural context of traditional Miao clothing design. To achieve innovative expression while preserving the core values of traditional culture, it is necessary to supplement existing generative mechanisms with culturally aware strategies, both at the data and generation logic levels. Therefore, this study further proposes targeted strategies for data training and the optimisation of generation mechanisms.

For AI to truly act as a ‘protector’ of Miao cultural heritage, it must incorporate considerations of cultural and community representation within its generative logic, not merely produce visually similar patterns. Firstly, during the data training stage, extensive cultural annotations should be introduced, providing more detailed cultural background information and relevant labels for traditional patterns. This enables AI not only to recognise the graphic structure but also to understand some symbolic meanings behind the patterns, such as ‘fish’ symbolising fertility and reproduction, and ‘spirals’ representing the cycle of the universe, thus maintaining their cultural depth. Subsequently, some specific cultural context parameters, such as specific functions and ceremonial occasions, can be preset during the training stage to guide AI to generate more

relevant patterns, enhancing their recognition and pertinence in modern expressions. Therefore, as long as cultural awareness is imparted during the training process and correctly guided by designers, AI has the dual potential of protection and innovation.



Fig. 2. Process of Applying Traditional Miao Patterns to Skirt Design Using the GAN Model

3.2 Interview Method

This study will adopt a qualitative research approach using semi-structured interviews, focusing on two key groups: Miao cultural inheritors and local artists/designers. The primary aim is to explore their perspectives on the integration of AI into the design of traditional Miao clothing patterns. Specifically, the research seeks to understand how these participants perceive the role of AI in the traditional design process and what potential they believe AI brings to this context. At the same time, the interviews will also seek to understand their evaluation criteria regarding the cultural shortcomings and innovative contributions of AI-generated models. Through comparative methods, the study will assess whether AI-generated designs achieve a balance between modern aesthetics and cultural continuity.

In addition, as a supplementary reference, preliminary feedback from ethnic fashion consumers will be considered to more fully assess the potential of AI-generated designs in terms of market acceptance and communicative value. Given the study's emphasis

on deep understanding and cultural contextual evaluation, it will focus on collecting high-quality and in-depth qualitative interview data.

Furthermore, to enhance the cultural adaptability and broader acceptance of AI design within traditional contexts, this study will incorporate a co-design approach. Miao cultural inheritors and consumers will collaborate in the AI-driven pattern design process by providing feedback on contemporary stylistic preferences and helping ensure the cultural depth and symbolic accuracy of the AI-generated patterns.

3.3 Results

This study is expected to demonstrate the cultural innovation potential of generative artificial intelligence in the pattern design of traditional Miao ethnic costumes. By integrating technical algorithms with cultural understanding mechanisms, AI can not only preserve the cultural connotations of patterns but also enhance the appeal of traditional clothing in contemporary contexts. The research results are expected to prove that the design works generated by AI strike a balance between visual aesthetics and cultural significance, helping to enhance the public's understanding and interest in Miao culture. Additionally, the study is expected to improve consumer acceptance and emotional engagement with intangible cultural heritage (ICH)-inspired fashion products. Ultimately, this research will offer a new pathway for the dissemination and revitalisation of traditional culture in the digital age, promoting the continuity and innovation of ICH within broader social contexts.

4 Research Contributions

For its theoretical contribution, this research aims to develop the application of the GAN model in the design of traditional ethnic minority intangible cultural heritage, seeking to explore the factors that make AI-generated Miao clothing designs more advantageous than those created by humans. It will also investigate consumer feedback on AI-generated Miao clothing designs compared to those generated by humans. At the same time, this study is the first to systematically apply Computational Creativity Theory to the field of AI-generated traditional ethnic costume pattern design. While this theory has long been used in the fields of cognitive science, digital art, and general creative systems, few studies have introduced it into the domain of intangible cultural heritage, especially in the AI-based design practices of Miao traditional clothing. This research expands the boundaries of applying computational creativity theory within the context of culturally sustainable design.

For its practical contribution, this study intends to explore the specific implementation path of generative AI technology in traditional Miao clothing design, offering new insights for interdisciplinary research (the fusion of AI and traditional culture) and laying the groundwork for future applications in other traditional cultural contexts. Meanwhile, this research seeks to provide new methods for the inheritance and innovation of Miao traditional clothing, which could potentially help mitigate the loss of Miao traditional culture caused by modernisation and contribute to increasing the appeal of Miao

clothing among young people and in international markets. Thus, it is in turn expected to enhance the recognition and dissemination of ethnic culture.

5 Conclusions

As it is shown in the present paper, Generative Adversarial Networks (GANs) could significantly contribute to a creative process of designing traditional patterns of Miao attire. GANs are designed not to replace the conventional design practices and craftsmanship, they are rather used as an instrument of collaboration, where designers explore new shapes at the same time keeping in mind cultural importance and maintaining cultural integrity. This is in line with the current aesthetics. The cultural annotations and contextual parameters are introduced into the generative process in the training of the GAN model as well as a co-design system in which Miao cultural communities are involved. This in turn improves the cultural meaning and the symbolic correctness of the results created, creating a balance between creative expression and cultural fidelity. In this way, the current research not only suggests a unique technical way of maintaining traditional Miao clothing culture and its new variations, but also creates a system of information and practicism that encourages the preservation of culture and digital innovations.

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