Innovative design of traditional patterns and exploration of cultural diversity symbiosis model in the context of digitalization

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Abstract: This paper takes the innovative design of traditional patterns as the research object, exploring the application of digital technology in the cultural diversity symbiosis model and its implementation path. First, traditional patterns are collected and digitized; pattern samples are extracted from folk art, historical documents, and intangible cultural heritage works, and structured storage is performed through image recognition and vectorization technology. Secondly, combined with the Generative Adversarial Network (GAN), the traditional patterns are transferred and reconstructed to generate innovative design solutions to ensure the continuity of their cultural elements. Then, the generated patterns are applied to a variety of design scenarios, including clothing, architectural decoration, and digital media design, through parametric design technology, and feedback data is collected using a user participatory design platform. Finally, based on the theory of multicultural symbiosis, the correlation between traditional patterns and modern design styles is established, and their adaptability and symbiosis in different cultural contexts are analyzed. The results show that the patterns generated based on GAN have a high innovation score. Digital technology can effectively promote the innovative design of traditional patterns. At the same time, it can realize the integration of tradition and modernity through the cultural diversity symbiosis model, providing a new path for the inheritance and development of intangible cultural heritage.

Keywords: Cultural diversity and symbiosis, Digital context, GAN, Innovative pattern design.

1. Introduction

Against the backdrop of rapid globalization and digitalization, the inheritance and innovation of traditional patterns face unprecedented challenges. On the one hand, with the acceleration of the modernization process, many traditional art forms have gradually been marginalized, resulting in the loss of their cultural connotations; on the other hand, the application of traditional patterns in modern design often shows a single form and lacks deep integration with contemporary aesthetics. This phenomenon not only weakens the vitality of traditional culture, but also affects its influence in modern society. Therefore, how to achieve the diversified coexistence of traditional patterns and modern designs while preserving cultural characteristics has become an important issue that needs to be solved urgently.

To address this issue, this paper adopts a variety of digital technologies to explore innovative design paths for traditional patterns. First, through the systematic collection and digital organization of folk art, historical documents, and intangible cultural heritage (ICH) works, this paper lays a solid foundation for subsequent design experiments. Secondly, the generative adversarial network (GAN) technology is combined to perform style transfer and morphological reconstruction, aiming to generate

innovative design solutions while ensuring the continuation of traditional cultural elements. Through these methods, this paper not only promotes the modernization transformation of traditional patterns, but also provides new ideas for the realization of cultural diversity and symbiosis model.

This paper will introduce the digital arrangement process of traditional patterns in detail, including sample collection and image processing technology; then explore the application of GAN in the innovative design of traditional patterns, as well as the specific steps of style transfer and morphological reconstruction; then discuss the implementation of parametric design technology and its application in different design scenarios; then, based on the theory of multicultural symbiosis, this paper will analyze the relationship between traditional patterns and modern design styles, and explore their adaptability and symbiosis in different cultural contexts; finally, the paper will summarize the research results and put forward future research directions and suggestions.

2. Related Work

In today's digital age, the innovative design and inheritance of traditional patterns face various challenges, and many studies have provided new ideas and methods for this. In order to solve the problem of material waste caused by tie-dyeing process, Zheng, et al. [1] proposed to simulate the dyeing effect of tie-dyeing by sound visualization technology to achieve pattern generation. Based on the analysis of the dyeing effect of the curling tie-dye technique, abstract line elements were extracted, and the Processing sound visualization technology was used to realize the programmatic expression of abstract elements. In order to enrich the generated pattern effect, design variables and parametric design were added, and four styles of tie-dye patterns were finally generated by combining audio. In order to inherit and carry forward the traditional patterns of Chinese Han Dynasty brocade, Mei, et al. [2] combined disciplines such as archaeology, design, color science, and design thinking, and based on the regenerative thinking of "shape, meaning, and color", integrated traditional patterns into modern clothing design in a diversified and innovative design form. Lu [3] proposed and explained the new findings on Yangjiang kite patterns, and pointed out that the Yangjiang kite patterns were too realistic and too conservative in design. Based on this, he explored new directions in design thinking and innovated the patterns of Yangjiang kites, trying to improve the recognition of the patterns of Yangjiang kites and make them more in line with the aesthetics of modern people. In order to explore innovative design methods for houndstooth and provide reference for other styles of clothing pattern design attempts, Wang and Sun [4] studied and analyzed the formation principles and application fields of grating animation, constructed a pattern design model based on the principle of grating animation, and gave a mathematical expression for the relationship between grating parameters and animation frame number. In response to the problems of insufficient manpower, low design efficiency and slow development of clothing innovation in the innovative design of traditional Dai clothing patterns, Pan, et al. [5] proposed an improved algorithm based on neural style transfer and Gram matrix reconstruction based on the VGG network to quickly fuse and generate traditional Dai clothing patterns. Corsaro and Anzivino [6] proposed a conceptual model to explain value creation in a digitally connected B2B business environment. Liu [7] placed tactile geography and family geography in a digital environment and explored the digitalization of everyday family behaviors in organization and management. Jensen, et al. [8] explored how university faculty perceive the differences between physical campus environments and digital teaching environments for online courses. Meghini, et al. [9] aimed to introduce the goals and scope of the new Dante Annotated Digital Library. Mialkovska, et al. [10] explored the implementation of media text discourse positions in digital environments, strategies and scenarios for presenting and evaluating information, and image creation. These studies not only enrich the expression of traditional culture, but also open up new directions and possibilities for future design practice.

3. Methods

3.1. Digitalization of Traditional Patterns

The digitization of traditional patterns takes on the various tasks of digital preservation and continuity of cultural heritage. Normal collection procedures of traditional patterns may include folk art, historical documents, and intangible cultural heritage. Moreover, substantial patterns from several regions and various nationalities are ensured to make the samples very diverse and representative. More than 500 traditional patterns have been collected during the whole process, each one carrying a profound cultural connotation and unique artistry. Next, these collected patterns are subjected to image recognition technology processing, followed by the use of specific high-resolution scanning and digitization equipment that ensures that all patterns are stored in high definition. Lastly, the bitmap is vectorized, turning it into editable vector graphics. This enables the design to be more manageable and modification in the future easier. At last, the reconstructions are all collected neatly and stored in a single database for general query and usage in the future. During the digitization process, the cultural background, meaning, and related literature of each design were documented for reference in further research. As a result of this documentation, a database with samples of traditional patterns was created to give deeper understanding and protect traditional culture. Table 1 is the data of pattern samples involved in the digital sorting process:

Table 1.
Pattern sample data.

Pattern Type	Source Category	Quantity	Cultural Region
Folk Art	Folk Art	200	Various Ethnic Groups
Historical Documents	Documented Sources	150	Major Historical Areas
Intangible Heritage	Intangible Culture	100	Various Local Cultures
Modern Design Application	Application Cases	50	Modern Design Industry
Total		500	

3.2. Application of GAN

3.2.1. Style Transfer and Morphological Reconstruction Process

This study applies the GAN model to the style transfer and morphological reconstruction of traditional patterns to enhance the innovation and expressiveness of modern design. In this context, the Pix2Pix and CycleGAN architectures were chosen, the former is suitable for supervised style transfer, and the latter is more suitable for unsupervised image conversion tasks. The combination of these two models can achieve countless reconstructions of traditional patterns. In the style transfer process, samples of traditional patterns are first input into the generator of the GAN model to convert the input pattern into the target style. This involves extracting and transforming features of traditional patterns and processes by applying convolutional and deconvolutional layers, allowing them to be incorporated into modern design styles while retaining elements of their original culture [11]. To further improve the effect of the style transfer process, we also added a style loss function to the toolbox to encourage all generated patterns to have physical similarities with the target style. Then we enter the morphological reconstruction stage, where the GAN discriminator plays a key role. The discriminator provides feedback by comparing the generated pattern with the real pattern, helping the generator to continuously optimize the output results. Through multiple iterations of training, the generator gradually learns to create innovative pattern designs based on traditional patterns.

3.2.2. Generation of innovative design solutions and continuation of cultural elements

In the design solution generation stage, the trained GAN model, especially the generator combined with style transfer, was used to create new design solutions. First, the extracted cultural features are combined with modern design concepts to formulate design goals [12]. Designers set specific modern application scenarios for each traditional pattern to provide a clear direction for the generation process. Next, the GAN generator is used to input these set goals and extracted features to generate multiple

candidate design solutions. The iterative process of training each solution is to improve the details and overall visual effect of the pattern. During this process, we place great emphasis on cultural continuity – ensuring that the resulting patterns are not only aesthetically pleasing, but also convey the rich meaning of the original culture. Finally, the key design solutions are determined through a feedback loop between designers and cultural experts. Experts evaluate the generated patterns to ensure that each design solution can integrate traditional and modern elements, combine innovative design depth with cultural context and market, and improve competitiveness.

3.3. Implementation of Parametric Design Technology

This study will apply the generated traditional patterns to various design scenarios, including clothing, architectural decoration, and digital media design, through parametric design technology [13]. Parametric modeling through Grasshopper tools allows designers to change the parameters of the pattern according to different design requirements. This will enable the generated pattern to adapt to various environmental contexts and product lines, thereby improving compliance with design standards and introducing dimension into the design. In fashion design, appliqués are incorporated into styles. Designers use different pattern placements and proportions on fabric to create a unique collection of clothing [14]. In architectural decoration, patterns are applied to the decorative design and decoration of walls, ceilings and floors, where parametric technology can achieve dynamic changes, making the architectural space more artistic. Digital media design uses animation and interactive effects to display traditional patterns and enhance user experience. In order to evaluate the design effect, a user participatory design platform is used to collect feedback data. Participants rated the patterns in each design scenario online, covering multiple dimensions such as visual appeal, cultural identity and practicality. Table 2 is an overview of the feedback data:

Table 2.
Feedback data.

Design Scenario	Satisfaction Rating (%)	Acceptance Rate (%)	Interaction Experience Rating (%)	Number of Participants
Fashion Design	85	80	N/A	150
Architectural Decoration	78	75	N/A	120
Digital Media Design	N/A	N/A	90	100
Total				370

4. Results and Discussion

4.1. Establishment of Correlation

Based on the theory of multicultural symbiosis, the correlation between traditional patterns and modern design styles was established. This theory emphasizes finding common ground in diversity and promoting the integration and coexistence of different cultural elements. First, the research team conducted an in-depth analysis of the cultural background and symbolic meaning of traditional patterns, identifying their core elements, including colors, shapes, lines and the cultural values they convey. Comparing these traditional elements to modern design styles and look for intersections between the two. For example, the geometric shapes found in certain traditional patterns are a natural fit with modern minimalist design styles, allowing them to showcase a modern aesthetic while maintaining cultural roots. In addition, in terms of color application, the natural colors in traditional patterns and the popular colors in modern designs can create a harmonious visual effect through the combination of color theory. In the process of establishing associations, this paper analyzes adaptability and symbiosis in different cultural contexts. For example, in East Asian culture, traditional patterns are often closely linked to natural elements, while in Western modern design, simplicity and functionality are emphasized. Through comparative analysis, we found that adaptable design can effectively balance traditional and modern elements, creating design works that have both cultural depth and modern aesthetics.

4.2. Innovation Score and Cultural Retention Rate

20 pattern design practitioners were selected to compare the patterns generated by GAN in this paper with those generated by traditional ANN. The innovation score ranged from 1 to 10, with 1 indicating lack of innovation and 10 indicating high innovation. Figure 1 shows the innovation score results, and Figure 2 shows the test results of cultural retention rate:
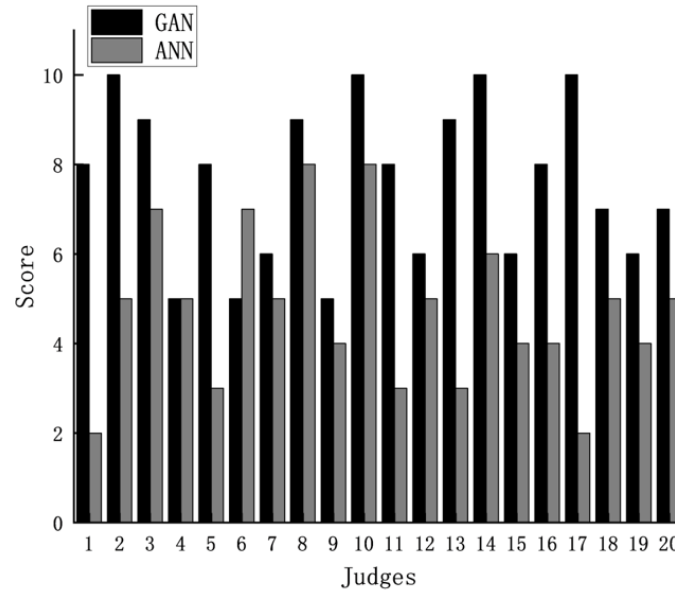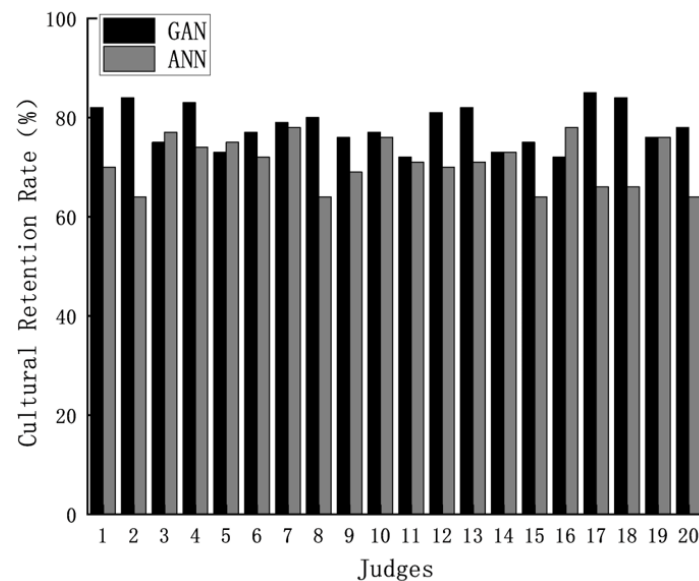

Figure 1.
Innovation rating.

Figure 2.
Cultural retention rate.

According to the analysis of the innovation scores and cultural retention rate data of 20 pattern design practitioners, the patterns generated based on GAN are significantly better than those generated

based on traditional ANN in terms of innovation scores. The former has a score range from 5 to 10, with an average innovation score of 8.1, while the latter has a score between 2 and 8, with an average of 5.1. This trend shows that GAN' s generation ability is more flexible and creative, and can better integrate modern design concepts with traditional cultural elements. In addition, cultural retention rate data shows that the retention rate of patterns generated by GAN is generally high, up to 85%, while the retention rate of patterns generated by traditional ANN is generally lower than 78%. This shows that GAN can more effectively preserve the core features of traditional culture while innovating design, reflecting its advantages in style transfer and morphological reconstruction. The reason for this phenomenon may be the adversarial training mechanism of the GAN model, which makes it better at capturing and reconstructing complex cultural elements, while traditional ANN is limited by its structure and finds it difficult to achieve the same effect. This dual advantage of innovation and cultural preservation reflects the huge potential of digital design technology in the innovation of traditional patterns, and provides important theoretical support and practical value for future design practice.

4.3. Analysis of Changes in Market Acceptance

Market acceptance is reflected by sales. We selected 30 days a month to investigate the sales of images generated by different methods. The survey results are shown in Figure 3.
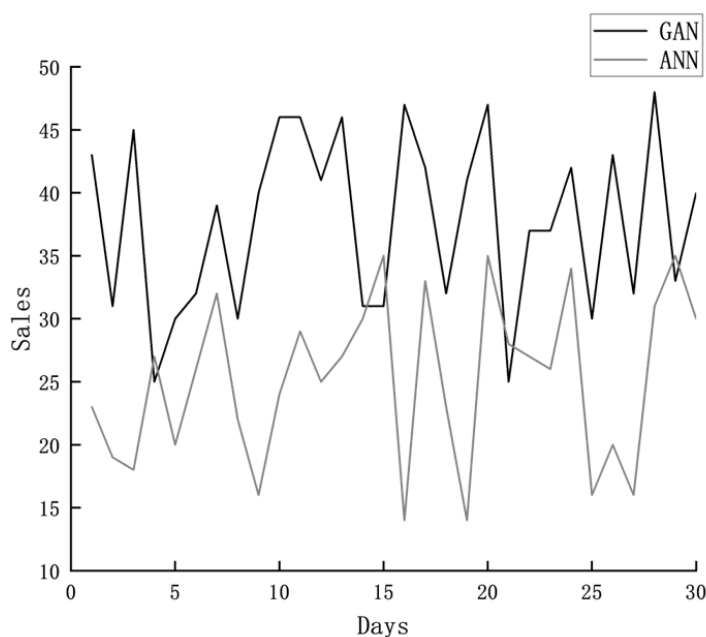

Figure 3.
Sales volume.

According to the survey results of the sales of patterns generated by different methods within 30 days of a month, it can be clearly seen that the GAN-based design performs better than the traditional ANN design in terms of market acceptance. First of all, looking at the daily sales data, the sales of patterns generated by GAN are higher than those of patterns generated by ANN on most days, especially at key moments such as the 1st, 3rd and 10th days, when the sales of GAN reach 43, 45 and 46 respectively, significantly exceeding the sales of ANN. By calculating the total sales for the entire 30 days, the total sales of GAN are 1,129, while the total sales of ANN are 747, showing that the patterns generated by GAN have stronger appeal in terms of overall market performance. Further analysis of the sales fluctuations on each day shows that GAN sales have shown a relatively high stability overall.

Although sales have slightly decreased on some days, the overall trend is still upward, indicating consumers' continued interest in GAN-generated patterns.

5. Conclusion

In the context of digitalization, the exploration of innovative design of traditional patterns and cultural pluralism symbiosis models shows that digital technology not only provides a new path for the inheritance of traditional culture, but also brings unlimited possibilities for design innovation. By comparing GAN and ANN, this study reveals the significant advantages of GAN in improving pattern innovation and market acceptance. The patterns generated based on GAN not only excel in visual beauty and retention of cultural elements, but also gain higher recognition in the market, reflecting the effective integration of digital technology and traditional art. However, the sample size and time span of this study are relatively limited. Future research can expand the sample range to cover more types of traditional patterns and design styles. Secondly, the collection of user feedback mainly relies on quantitative data and lacks in-depth qualitative analysis of the design process, which may lead to a one-sided understanding of user needs and cultural background. In the future, with the continuous development of digital technology, the innovative design of traditional patterns can be further combined with emerging technologies such as virtual reality (VR) and augmented reality (AR) to create a richer interactive experience.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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