



Exploration of Dunhuang Pattern Digital Design and Cultural Inheritance Strategies in the Perspect

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Abstract. This study focuses on the use of emerging technologies to promote the innovative development and effective inheritance of Dunhuang patterns in contemporary society. Using a combination of literature research, case study analysis and practical exploration method, the research status of AIGC technology and Dunhuang patterns is analyzed, typical digital design cases are analyzed and practiced, and the application of AIGC is explored in depth. The innovation lies in systematically combining the two, proposing cultural inheritance strategies from the perspective of digital technology, and constructing a complete inheritance system. The use of AIGC technology brings new innovative opportunities for the digital design of Dunhuang patterns, which is conducive to the breakthrough of the traditional inheritance dilemma, and achieves the synergy of cultural inheritance and innovation.

Keywords: AIGC; Dunhuang pattern; digital design; cultural heritage

1 Introduction

In the booming development of digital technology, new media technology is reshaping artistic expression, dynamic images, interactive design and other fields to inject new vitality for artistic creation and traditional cultural inheritance. the rapid development of AIGC technology, widely penetrated into various fields, bringing changes to the cultural and creative industries. Dunhuang patterns, as traditional cultural treasures, face the challenges of low efficiency and limited dissemination of traditional design. The introduction of AIGC technology into the digital design of Dunhuang patterns has become the key to solving the problem. Not only can greatly improve the design efficiency and creativity, giving Dunhuang patterns the vitality of the times, but also through digital design and the Internet, broaden the dissemination channels, enhance the cultural influence, and carry forward the excellent traditional Chinese culture[1-6] is of great significance.

2 AIGC Technology Overview

2.1 Traceability of AIGC Concepts

AIGC, or Artificial Intelligence Generated Content, is a new type of production method that utilizes In the digital era, AIGC technology is revolutionizing the design field. With powerful machine learning algorithms, AIGC learns from massive design data, accurately recognizes the details of various design elements, such as the angles and lengths of geometric elements and the curvature of organic elements, and quantifies them to form a digital element library. Based on the integrated database, AIGC can use advanced technology to generate a variety of innovative design samples, dramatically improving design efficiency, expanding the boundaries of innovation and application scenarios, and leading the development of design towards digitalization and intelligence.

2.2 Digital Development of AIGC

Artificial intelligence technology to automatically or semi-automatically create new content based on existing knowledge and data, which covers a wide range of forms such as text, images, music, videos, and so on. Unlike PGC (professionally generated content) and UGC (user-generated content), AIGC realizes the transformation from analytical to generative with the help of machine learning, deep learning and other technologies, transforms human-machine interaction, and promotes the synergistic development of human and machine with natural language understanding, greatly reducing the threshold of content creation, and stimulating the diversification and unique value of design and creation.

3 Dunhuang Pattern Digital Development Status Quo

3.1 Overview of Dunhuang Patterns



Fig. 1. Lotus pattern

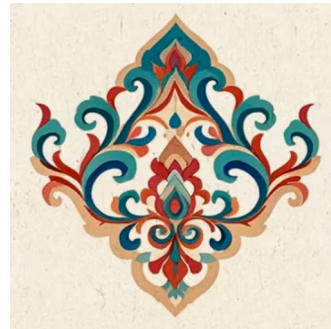


Fig. 2. Lonicera pattern

Dunhuang patterns have a long history and have evolved over many dynasties, with a rich variety of patterns, including geometric patterns, botanical patterns, animal

patterns, figure patterns and so on. These patterns not only have high artistic value, but also contain deep cultural connotations, reflecting the religious beliefs, social life, aesthetic concepts and so on. For example, as shown in Fig. 1, the lotus pattern is a symbol of Buddhist culture, reflecting people's desire for purity and beauty; and as shown in Fig. 2, the Lonicera pattern combines elements of Chinese and Western cultures, demonstrating the charm of cultural exchange and fusion.

3.2 The Digital Gene of Dunhuang Culture

In the digital context, Dunhuang culture shows its unique value and great potential. The symbolism and detachability of the flying sky, algal well patterns, and mural color system provide rich materials for digital creative design. For example, the flying sky, with its lithe posture and fluttering sash, symbolizes the romantic spirit of Dunhuang art, and elements such as body movements and clothing textures can create fantastical visual effects in animation production. The unique geometric shape and exquisite patterns of the algal well pattern can be extracted from a single pattern for the digital product interface, adding a simple and elegant temperament.

3.3 Dunhuang pattern Digitization Development Status Quo

The digital development of Dunhuang patterns has gone through many stages. Early record archiving, relying on text and other preservation patterns. Later into the technology to explore the application period, VR, 3D printing to help display dissemination. In recent years, with the development of artificial intelligence, into the depth of integration and innovation stage, AIGC technology began to apply, but the model is not mature. The "Digital Dunhuang" project has achieved outstanding results, realizing the global online exhibition. However, there are problems in the development, such as insufficient digitization accuracy of some patterns, a single form of application, focusing on display, and insufficient design innovation, cultural heritage excavation and integration with modern life, making it difficult to meet the diversified cultural needs of the public.

3.4 Application of AIGC Technology in Dunhuang Pattern Design

AIGC technology brings changes and opportunities to the digital design of Dunhuang patterns. When extracting pattern elements, its powerful image recognition and analysis capabilities can accurately extract classic patterns from Dunhuang murals and build a digital library of elements. In the design generation process, AIGC utilizes deep learning algorithms to create innovative combinations of patterns based on styles, themes, and scenarios to generate Dunhuang-themed digital posters, cultural and creative patterns, and other design solutions. In addition, AIGC simulates material effects to enrich the visual presentation of patterns, breaking through traditional limitations, improving design efficiency and creativity, and helping Dunhuang patterns develop in the digital era.

4 The Development Characteristics of Digital Design of Dunhuang Patterns under the View of AIGC

4.1 Technology-led Efficient Creation

The efficiency of digital design of Dunhuang patterns has been revolutionized under the vision of AIGC, which, with its powerful algorithmic capability, can generate a large number of design solutions in a very short time. Designers only need to enter keywords, style preferences and application scenarios related to Dunhuang patterns, such as "Generate a pattern design for the navigation bar of a modern web interface based on the style of Dunhuang mural paintings in the Tang Dynasty", and the AIGC tool can quickly filter and integrate the elements in the library of Dunhuang patterns, complete the composition, color matching and detail optimization work, and output multiple sets of digital designs. The AIGC tool can quickly filter and integrate the elements in the Dunhuang pattern material library, complete the composition, color matching and detail optimization, and output multiple sets of first drafts, which greatly shortens the design cycle and provides sufficient time for creative iteration.

4.2 Deep Cultural Integration and Expansion

AIGC promotes the deep intermingling of Dunhuang patterns with multiple cultures. On the one hand, it mines the history, religion, folklore and other cultural connotations behind Dunhuang patterns and combines them with modern cultural concepts. For example, with the concept of harmonious coexistence of man and nature embedded in Dunhuang patterns as the core, it designs digital posters on environmental protection themes, conveying ancient cultural values through modern visual language. On the other hand, to promote cultural exchange and mutual understanding between Dunhuang patterns and the rest of the world, AIGC helps designers integrate Dunhuang patterns with cultural elements from different countries and regions to create designs with an international outlook, such as fusing Dunhuang Flying Skies with Japanese ukiyo-e styles to create a unique artistic style that will bring Dunhuang culture to a wider audience around the globe.

4.3 Innovative Expression of Multidimensional Elements

With the help of AIGC, the digital design of Dunhuang patterns realizes the innovative expression of multi-dimensional elements. In terms of element extraction, AIGC accurately analyzes Dunhuang murals and extracts core elements such as flying skies, algal wells, and curly grass patterns, as well as tapping into hidden elements such as color matching and line trends. In the combination of innovation, breakthroughs, will be different periods, styles of Dunhuang pattern elements cross-border reorganization, and modern technology, pop culture elements collision, such as the Dunhuang pattern and cyberpunk elements fusion, to create a very futuristic digital works. When expanding application scenarios, the combination of elements can be flexibly adjusted according to the needs of different scenarios, be it digital exhibitions, cultural and creative

products, or virtual spaces, all of which can be accurately adapted to convey the charm of Dunhuang culture with novel expressions!

5 The Cultural Inheritance Strategy of Dunhuang Patterns Digital Design under the View of AIGC

5.1 Precise Communication of Cultural Connotations

When utilizing AIGC to digitally design Dunhuang patterns, a strict cultural audit mechanism should be established. In the design process, AI trainers and Dunhuang cultural researchers should work closely together to review the cultural connotations of the content generated by AIGC to ensure that the cultural information conveyed by the pattern is accurate. For example, for some patterns with specific religious symbols, they should be designed in strict accordance with the historical and cultural context to avoid cultural misunderstanding. Through digital means, the cultural connotation of Dunhuang patterns is deeply interpreted and explained. You can make relevant digital animation, virtual reality experience, etc., so that users can more intuitively understand the historical story behind the Dunhuang pattern, cultural symbolism, and enhance the sense of cultural identity.

5.2 Balance Between Cultural Heritage and Innovation

In the era of AI and digital design, achieving a balance between cultural heritage and innovation of Dunhuang patterns is the key to revitalizing this ancient cultural treasure. AI technology, with its powerful image recognition capabilities, accurately analyzes Dunhuang murals, extracts classic elements such as the Flying Sky and the Lonicera pattern, and builds a digital library of basic elements, preserving their cultural connotations and laying a solid foundation for subsequent creations. In the design application, designers need to use digital means to respect the tradition of Dunhuang pattern, retain its shape, color and composition, combined with modern aesthetic and life needs innovation. For example, designing Dunhuang-themed cultural creations, borrowing traditional colors to convey ancient charm, and using interactive design to add practical value. Encourage the creation of narrative artifacts inspired by Dunhuang's multicultural dimensions.

5.3 Cultural Dissemination and Promotion

AI and digital design have opened up new avenues for the cultural dissemination and promotion of Dunhuang patterns. With AI big data analysis, the digital media platform accurately grasps the preferences of different audiences, pushing articles and documentaries analyzing the artistic value of Dunhuang patterns to art lovers, and displaying fashionable items incorporating Dunhuang patterns for young trendsetters. AR and VR technologies enable people to "walk into" Dunhuang caves at home and see exquisite patterns up close. The AR and VR technologies enable people to "enter" Dunhuang

caves at home and see the exquisite patterns up close. For example, with Dunhuang-themed AR interactive products, users can scan the pattern and witness the flying sky dancing in real life scenes, visualizing the charm of Dunhuang.

6 Digital Design Practice of Dunhuang Patterns in the Perspective of AIGC

AIGC technology promotes the integration of digitalization and cultural and creative products, which has become the development trend of non-heritage culture, and is gradually replacing the PGC and UGC creation modes. Cutting-edge technologies such as GAN, Transformer, Diffusion and so on allow AI to have generative capabilities, empowering the innovation of non-heritage cultural and creative products, and the potential for digital design of Dunhuang's treasure phase pattern is huge. AIGC is widely used in the four major aspects of the design, and there are various ways to implement it. As shown in Table 1, in this paper, with the help of relevant high-frequency tools, we explore the way of AIGC to help Dunhuang treasure phase pattern digital design.

Table 1. How AIGC technology types are implemented in the design process

Type	of technology	design process			
		Design Research	design proposal	Design outputs	Design public-ity
Text Gener-ation	Chatgpt in a word Deepseek	Digging deep into the user data, insight into consumer psychology	Data processing facilitates prob-lem analysis	Styling assistance support	Personalized Copywriting
Image Gen-eration	Midjourney Stable Diffu-sion beanbag	Multi-style acquisition and innovative fusion	Design Program-ming and Updat-ing	Graphical extrap-olation of iterative trajectories	Creation of promotional materials
Audio Gen-eration	Speechify StableAudio	Comprehensive analy-sis and mining of source data	Preset design styles	Multimodal sound marking	Audio Tracks User's Manual
Video Gen-eration	Domo AI RunWay	Video footage capture and content extraction	Prototyping and optimization	Dynamic evolu-tionary mapping construction	Digital Media Diffusion Workshop

6.1 Disassembly Analysis and Redesign of Poisson Pattern Using AIGC

With the help of AI technology to extract and analyze the elements of the Dunhuang Baoxiang flower pattern, we can accurately understand its unique charm.AI can start from a large number of Baoxiang flower image data, and use image recognition and data analysis algorithms to extract its key elements. the stamen of the Pohang flower is the core, which is in the form of multi-layered concentric circles, with rich forms, either symbolizing the seed of life, or symbolizing the light of the sacred, showing the

solemnity. The petals are a blend of natural floral elements, with various styles such as side scrolling petals, rich layers and orderly combinations, presenting different flower styles. The leaves of the flowers are spreading, incorporating cloud patterns and other elements, with smooth lines, adding vitality. The overall outline is mostly round, with the stamen as the center, and the petals and leaves distributed in a radial symmetry, with a strong sense of order, showing the pursuit of formal beauty in Dunhuang art.



Fig. 3. Reference generation of the treasure phase pattern

Integration of AIGC's elemental analysis and sample generation, combined with the design purpose and design ideas for pattern design, the design process is shown in Fig. 4, and the reference generation effect is shown in Fig. 3.

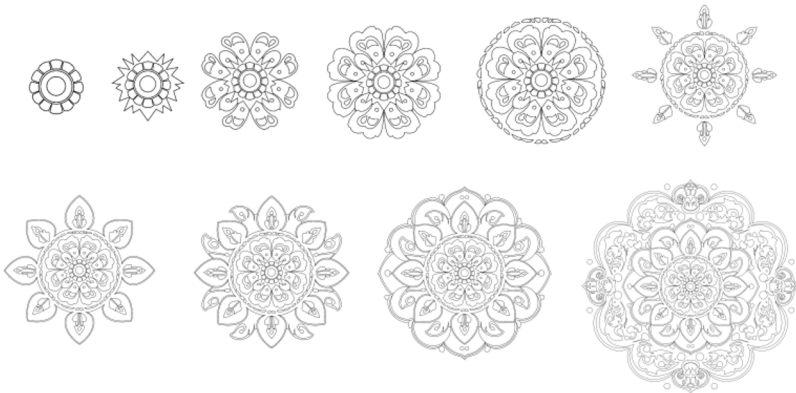


Fig. 4. Tattoo design process

6.2 Using AIGC to Analyze the Traditional Color Matching and Redesign of Dunhuang Patterns

Under the wave of digitization, AIGC technology has opened up a new path for research and design innovation in traditional color matching of Dunhuang patterns. With its powerful image recognition and data analysis capabilities, AIGC can accurately analyze the traditional color matching system of Dunhuang patterns, which has been deposited over thousands of years. Through the deep learning of massive Dunhuang mural images, it can extract key information such as the frequency of colors, collocation

patterns and hue tendencies, and explore the cultural connotations and artistic laws hidden behind the colors. Fig. 5 shows.



Fig. 5. Reference generation of the color scheme for the treasure phase pattern

According to the color scheme summarized by AIGC, the color combinations for the patterns are selected to fit their styles and themes, breaking the limitations of traditional coloring and integrating modern aesthetic needs, so that the ancient Dunhuang patterns are revitalized in the new design, and the deep integration of traditional culture and modern design is realized. The design process is shown in Fig. 6.



Fig. 6. Design process of pattern color matching

6.3 Digital Technology Realization Process

AE (After Effects) and TD (TouchDesigner) software play a key role in the digital design of Dunhuang patterns. First of all, when designing with AE, the material of Dunhuang patterns is imported, and the patterns are drawn and adjusted through shape layers, masks and other functions. Using its rich special effects plug-ins, add light and shadow, color change effects for the pattern, simulating the traditional mural texture. TD software focuses on interaction design, through the creation of node networks, to realize the interaction between the pattern and the user. For example, by setting up the touch sensor, when the user touches the screen, the Dunhuang pattern can change

dynamically. Combining the two, AE first completes the basic visual design of the pattern, and then TD gives it interactivity, realizing the digital design process from static to dynamic, from display to interaction.

6.4 Presentation of Results

The final Dunhuang Baoxiang pattern digital design is presented in the form of a video. The Baoxiang pattern starts from the ancient and simple traditional shape, and is dynamically interpreted, with the pattern spreading out layer by layer. Through different styles of dynamic effects, such as pixelated changes, color flashes and flows, etc., it gives a sense of modern technology. It not only shows the symmetrical and strict, layered core features of the Baoxiang pattern, but also through the dynamic design, makes the traditional pattern, which contains the meaning of "Bao" and "Xian", revitalized in the modern context of contemporary digital design, and realizes the perfect fusion of traditional culture and digital art. The perfect fusion of traditional culture and digital art is realized. The related video screenshots are shown in Fig. 7.

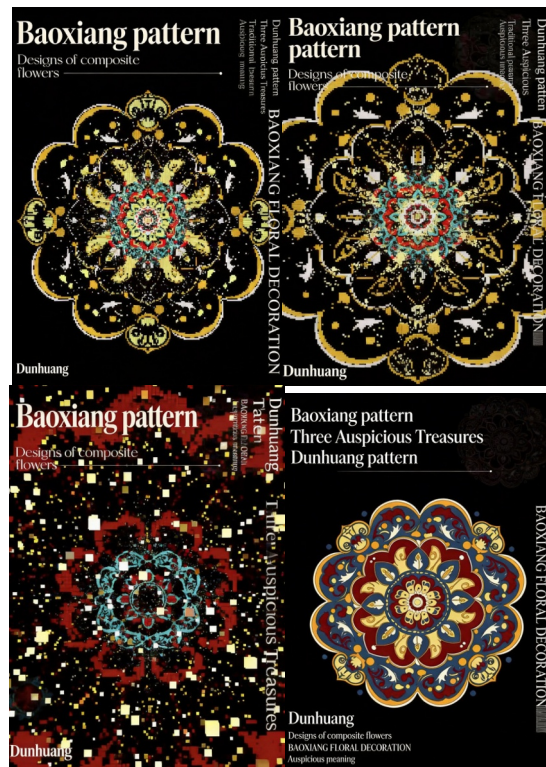


Fig. 7. related video screenshots

7 Concluding Remarks

AIGC has opened a new path for digital design and cultural heritage of Dunhuang patterns. Although there are many challenges at the moment, there is great potential for development. In the future, AIGC technology will continue to advance, promoting smarter and more personalized design of Dunhuang patterns, and combining it with virtual reality and other technologies to bring a new experience. We believe that with AIGC, Dunhuang patterns will shine in the global cultural arena, realizing the inheritance and innovation of China's outstanding traditional culture, and promoting in-depth exchanges and fusion between different cultures.

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