

Research on innovative design of AI technology in Xiang embroidery, an intangible cultural heritage

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ABSTRACT

In the digital age, Xiang embroidery, a national intangible cultural heritage, still faces three major challenges: a talent gap, technical limitations, and slow industrial transformation. Therefore, it is urgent to leverage AI technology to overcome these challenges and infuse new vitality into Xiang embroidery. By using generative design, we can innovate patterns across time and space; intelligent simulation technology can address the challenge of standardizing techniques; and the metaverse can be used to build virtual embroidery workshops to tell cultural stories. The deep integration of Xiang embroidery and AI will further integrate design, production, and marketing, promoting intelligent production management and blockchain rights confirmation, forming an innovative model that combines 'technology empowerment + humanistic core.' This approach not only enhances efficiency but also preserves the essence of craftsmanship, providing solutions for the digitalization of intangible cultural heritage and highlighting the vitality of traditional skills in the digital age.

KEYWORDS

AI technology; Xiang embroidery; innovation

In today's digital and intelligent environment, the integration of traditional skills and modern technology has become an important trend of cultural inheritance and innovation. As an ancient folk traditional handicraft in China, Xiang embroidery is colliding with artificial intelligence AI to produce different sparks, showing unique charm and value.

1 Digital dilemma of Xiang embroidery inheritance and AI breakthrough path

Since 2006, when Xiang embroidery was first included in the national intangible cultural heritage protection list, efforts to inherit, protect, innovate, and develop Xiang embroidery have been fully launched. In terms of talent development, the Xiang Embroidery Art College was established at Hunan Institute of Arts and Crafts in 2006, offering a specialized program in Xiang embroidery and pioneering a 'master studio + product + workshop' integrated work-study model for full-order talent training. For product innovation, the Shaping Xiang Embroidery Production Area has partnered with several local universities to establish the Xiang Embroidery Innovation Research and Development Center, a platform for industry-university-research collaboration focused on the innovation, creative design, and digital key technologies of Xiang embroidery products. Despite the establishment of an inheritance system that integrates 'college + workshop + industry,' the sector still faces three major challenges in the digital age:

1.1 The "fault line crisis" of talent training

In the preservation and inheritance of Xiang embroidery, numerous challenges persist, including the collective bottleneck in intangible cultural heritage protection, difficulties in building a talent ladder, insufficient innovation in the education system, weak industrial ecosystem support, severe loss of reserve talents after employment, and the traditional 'master-apprentice' model being unable to adapt to the modern education system. These issues have led to a triple challenge in the inheritance of Xiang embroidery: difficulty in training, retaining, and innovating. Although the college has introduced innovative courses like 'digital pattern analysis,' less than 15% of teachers are proficient in both needlework techniques and 3D modeling, limiting digital teaching to mere image recording. The Xiang embroidery inheritance team has not yet integrated professional collectors into the talent reserve system for inheritance, resulting in a severe shortage of individuals who understand both intangible cultural heritage and modern digital technology.

1.2 "Data islands" of technology applications

According to relevant research, most of the existing digital archives of embroidery are low-resolution flat scans, with only a few completed three-dimensional dynamic collections. Compared to the industry standard of 0.01mm 3D modeling accuracy for the Louvre's artifacts in France, the digital reproduction of Xiang embroidery stitch details is less than 60%, which limits the possibilities for virtual restoration and innovative design.

In the field of digital research on intangible cultural heritage (ICH) protection, the main areas of focus include digital

archives, digital museums, digital design, and online sales. The primary focus of digital work is on the collection and preservation of materials, with a focus on text and images. The clarity of images and backup methods are relatively basic, and the application of 3D modeling, VR technology, and motion capture techniques is not widespread.

1.3 "Value gap" in industrial transformation

According to the 2023 Hunan Province Intangible Cultural Heritage White Paper, online sales of Xiang embroidery products account for only 12% of the industry's total revenue, with 70% being low-end tourism items. The lag in building a traditional pattern database has led to severe design homogenization, and there are fewer than three digital co-branded projects with international luxury brands like Hermes. Currently, Xiang embroidery faces significant challenges in brand building and market promotion, including an incomplete brand system, less than 30% international recognition, low efficiency in digital communication, insufficient professionalization in new media operations, and a lack of in-depth exploration of cultural connotations, as well as a lack of systematic IP development and protection mechanisms.

2 AI helps the digital protection and innovation of Xiang embroidery

2.1 Generative design: reconstructing the aesthetic language of intangible cultural heritage

AI technology plays a crucial role in the design of Xiang embroidery patterns. By deeply learning from traditional Xiang embroidery designs, AI can generate new design elements that blend modern design concepts, creating patterns that retain traditional charm while meeting contemporary aesthetics. The Adobe AI-drawn original pattern intangible cultural heritage database integrates traditional Xiang embroidery motifs with other elements to cater to diverse user needs. Using StyleGAN algorithms, the system analyzes 2,000 late Qing dynasty embroidery pieces to develop a deep learning model that includes 43 basic stitching techniques and 158 color transitions. This system can automatically generate innovative patterns with distinct regional cultural characteristics, integrating the embroidery patterns from the Mawangdui Han Tombs with the glaze colors of the Changsha Kiln across time and space. Additionally, the human-machine collaborative creation system offers new perspectives for Xiang embroidery pattern design, enhancing designers' creativity.

2.2 Intelligent process simulation: solve the problem of skill standardization

Based on the technical characteristics of 'hair-pressing needles' and 'dyeing needles,' motion capture technology is used to record the angles and forces at which the embroiderer's fingertips manipulate the silk threads, constructing a mathematical model that captures the fluffiness of the silk and the texture of the hair. By integrating AI deep learning of the natural growth patterns of animal hair, the system can automatically generate needle paths that conform to anatomical features. To meet the concealment requirements of the 'hidden needle embroidery technique' in double-sided full-pattern embroidery, material mechanics simulation technology is employed to establish a model linking the penetration depth of the embroidery layer with the tension of the silk threads. A rendering engine is used to display in real-time the interweaving state of the silk threads on both sides of the base material, optimizing the density and sequence of the stitches to ensure that the contours of the double-sided pattern are perfectly aligned and the thread marks are seamless. By simulating the embroidery process of Xiang embroidery techniques, the production process of Xiang embroidery is optimized. This technology not only enhances production efficiency but also reduces errors caused by manual operations, ensuring consistent product quality.

2.3 Metaverse communication: building a new paradigm of cultural cognition

The digital twin workshop. AI technology has opened new avenues for the promotion of Xiang embroidery culture. By using intelligent imaging and digital twin technology, industrial-grade CT scanners are employed to capture 3D data of over 100,000 stitches. This data is then integrated with Unreal Engine5 to create an interactive virtual embroidery workshop, allowing users to experience the physical sensation of silk threads moving through tactile gloves. The intricate process of Xiang embroidery can now be vividly displayed, transcending time and space, and enabling a broader audience to appreciate this traditional craft.

3 Future outlook of the integration of Xiang embroidery and AI

The integration of Xiang embroidery with AI not only breathes new life into traditional crafts but also provides

innovative ideas for the cultural industry. In the future, as technology advances, AI will play a more significant role in the design, production, and marketing of Xiang embroidery. The combination of Xiang embroidery and AI represents a perfect blend of tradition and modernity. It not only rejuvenates ancient techniques in the new era but also offers new perspectives on cultural preservation. As AI technology continues to evolve, traditional crafts will have more opportunities for development, and we look forward to their shining even brighter in the new era.

4 Epilogue

The strategic integration of AI technology has transcended the traditional protection model's limitations in time and space, establishing a multi-dimensional system for the innovative inheritance of cultural heritage. The digital ecosystem driven by AI technology has created new mechanisms for value transformation in intangible cultural heritage projects, facilitating a shift from 'static protection' to 'living inheritance' in the preservation of Xiang embroidery. This has enabled Xiang embroidery art to transition from specialized inheritance to social dissemination.

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