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Application of AIGC in the Protection and Living Inheritance of Shu Brocade

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Abstract: As a national intangible cultural heritage, Shu Brocade embodies profound historical heritage and artistic value. However, its inheritance confronts challenges in the current era, such as the loss of inheritors, skill discontinuity, insufficient market adaptability, and the necessity to enhance the effectiveness of cultural communication. This paper takes AIGC as the core empowering tool. First, it clarifies the current status of Shu Brocade inheritance and its core dilemmas through literature analysis. Then, by combining the proven AIGC application paradigms in the field of intangible cultural heritage with the unique characteristics of Shu Brocade, it defines the integration logic and key entry points of the two. Finally, it proposes AIGC-based practical paths, including constructing a multi-dimensional Shu Brocade cultural knowledge graph to support model training, developing specialized sub-models for pattern lightweight processing, skill digitization transformation, and bilingual content generation, and building a multi-scenario communication system covering digital protection, innovative design, and living inheritance. The purpose is to provide a practical basis for the protection and inheritance of Shu Brocade and, at the same time, construct a reference paradigm for the integration of traditional craft intangible cultural heritage with advanced digital technologies.

Keywords: Shu Brocade; AIGC; digital protection; living inheritance

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1. Introduction

Shu Brocade, a quintessential representation of China's traditional silk weaving art and a vital custodian of Bashu culture, embodies exceptional artistic value and rich historical significance [1]. With a history spanning 3,000 years, it is celebrated for its intricate warp and weft techniques, vibrant patterns, ranging from the linked-pearl medallion hunting pattern of the Tang and Song dynasties to the elaborate badayun pattern in Figure 1, and harmonious color combinations [2-4]. These attributes have solidified its reputation as one of the four renowned brocades of China.

a) b)

Figure 1. Shu Brocade a) linked-pearl medallion hunting pattern; b) badayun pattern

In the current era of digitalization and marketization, Shu Brocade, recognized as a national intangible cultural heritage, faces dual challenges related to preservation and innovative development [5]. The core weaving techniques, such as "threading warp and weft," involve intricate procedures and extended learning cycles. Additionally, the aging population of core inheritors places some invaluable techniques at risk of extinction. Concurrently, the visual expression and functional attributes of traditional Shu Brocade patterns and product forms do not resonate with contemporary consumers' aesthetic preferences and practical needs. This misalignment restricts its application primarily to niche areas, such as cultural relics and museum collections, thereby impeding mass dissemination and market transformation [1] Although industry initiatives to incorporate Shu Brocade patterns into cultural and creative products have somewhat broadened its reach, challenges such as homogenized design styles and superficial cultural interpretations persist [6]. Against this backdrop, how to leverage AIGC technology for the digital preservation and innovative transformation of Shu Brocade has become a pressing issue for its sustainable inheritance, while meeting modern market demands and preserving its historical authenticity.

The main challenge of using AIGC to preserve and inherit Shu Brocade is bridging the cognitive gap and differences between its traditional hand-woven cultural essence and the digital representation of AIGC [7]. This integration process encounters several obstacles. First, the artisan spirit, technical expertise, and specific historical-cultural context inherent in traditional master-apprentice transmission cannot be fully translated into AIGC-recognizable instructions using current technological methods. Even basic digital replication can only restore the superficial visual aspects of patterns, failing to convey their historical significance and the core philosophy of preserving tradition while innovating. This limitation may result in a diluted cultural essence and homogenized visual styles in the generated content [3]. Secondly, Shu Brocade patterns embody multi-layered cultural implications that encompass regional folklore, religious beliefs, and historical narratives. However, the algorithmic logic of general AIGC models prioritizes visual feature extraction, resulting in a significant misalignment with the cultural semantic system of Shu Brocade, which complicates precise cultural translation

[7]. Thirdly, Shu Brocade patterns serve as predominantly holistic cultural symbols, and their cultural value necessitates a complete symbolic system. Direct decomposition may fragment cultural meanings, thereby requiring professional deconstruction to extract cultural elements that align with AIGC expression and to reconstruct them into reusable digital modules [8]. Fourthly, the dissemination value of Shu Brocade digital content is heavily contingent upon the depth of cultural connotation adaptation to specific application scenarios. Different contexts demand varying levels of precision and accessibility in cultural expression, necessitating intelligent strategies to achieve accurate mapping of cultural essence and visual forms across diverse digital platforms [9].

This study explores practical approaches to preserve and inherit Shu Brocade through AIGC technology. The research focuses on analyzing the craftsmanship characteristics and cultural significance of traditional Shu Brocade weaving, tracing the lineage of core techniques and cultural semantics of its pattern systems, evaluating AIGC's potential in digital archiving, pattern innovation, and cultural dissemination, and exploring the feasibility of integrating AIGC with Shu Brocade's intangible cultural heritage. Key technical dimensions include cultural semantic transformation, specialized model training, and multi-scenario content adaptation. The study proposes implementation strategies for AIGC-enabled Shu Brocade preservation [11-12]. It aims to provide theoretical support and practical guidance for AIGC-enhanced living heritage preservation, promote digital innovation and widespread dissemination of Shu Brocade, and contribute to the refinement of intangible cultural heritage systems.

2. Literature Review

2.1 Research Status of Intangible Cultural Heritage Inheritance of Shu Brocade and Shu Embroidery

Shu embroidery, one of China's four renowned embroidery styles, merges a distinctive aesthetic with exceptional craftsmanship [13]. Originating in the Sichuan region, its history dates back to the ancient Shu period, taking form during the Han and Tang dynasties and reaching its zenith in the Ming and Qing dynasties [14]. This embroidery technique employs various stitching methods to apply silkworm silk threads onto substrates such as satin, showcasing the unique characteristics of the Bashu region through vibrant colors and intricate stitches. The color representation achieves a visual effect of layered transparency and natural transitions, effectively capturing the light and shadow textures of objects [15]. The production process of Shu embroidery encompasses substrate selection, silk thread splitting, stitching techniques, and pattern design [16,17]. Patterns often draw inspiration from the distinctive flora and fauna of the Bashu region, frequently integrating traditional auspicious symbolism and elements of familial ritual culture [17]. Due to its intricate stitching system and the high skill requirements for artisans, Shu embroidery has long been recognized as a hallmark of high-quality craftsmanship [13].

Early research primarily examined the historical origins, craft characteristics, and cultural connections of Shu Brocade within Sichuan's local culture. In contrast, contemporary studies focus on its technical mastery, cultural significance, and preservation strategies. Scholars have investigated the translation of Shu embroidery elements and their cultural connotations in both technical and cultural contexts. Xu Lili

explored methods for translating Shu embroidery motifs into creative handmade jewelry designs, proposing concrete pathways for cross-disciplinary integration between traditional craftsmanship and modern accessories [16]. Zhang Yuan et al. conducted a decoding study of Shu embroidery patterns in cultural relics, using Shu Embroidery: Three Stars as a case study. This research transformed traditional motifs into design elements for leather products, thereby providing practical models for the regeneration of cultural relic patterns [18]. Yuan Yueming examined the familial ritual symbolism of dragon and phoenix patterns in Ming-Qing dynasty Shu embroidery, thereby enriching the cultural semantics of these motifs [14]. Through systematic analysis of Shu embroidery's artistic characteristics, scholars, including Shi Aiqin, argued that preservation efforts should maintain core traditional techniques while achieving an organic balance with modern aesthetic and functional demands, thus offering theoretical references for the transmission of intangible cultural heritage [13]. Meanwhile, Lin Yulin et al.'s research on innovative Shu embroidery pattern design provided both theoretical support and methodological guidance for the contemporary reinterpretation and creative application of traditional motifs through pattern deconstruction and element recombination [19].

The Chengdu Municipal Government has implemented a systematic framework to support the preservation and development of Shu embroidery through targeted policies and a three-year action plan (2025 – 2027). This framework encompasses various dimensions, including the cultivation of inheritors, industrial organization, and brand development, thereby establishing a robust institutional foundation for the enduring legacy of Shu embroidery [20]. Furthermore, practitioners have actively facilitated the integration of Shu embroidery techniques with contemporary cultural and creative industries, resulting in the creation of innovative products designed for a variety of lifestyle contexts. This transformation has elevated Shu embroidery from a traditional intangible cultural heritage skill to a modern cultural symbol that merges cultural significance with market dynamism, thus providing a model for the living inheritance of intangible cultural heritage [16,17,21].

2.2 AIGC Technology Development

The evolution of AIGC can be divided into three distinct stages: technological accumulation, rapid expansion, and systematic standardization. Its technological core has shifted from specialized models, such as Generative Adversarial Networks (GANs), to large-scale model-driven general-purpose generation systems. In the initial stage, generative AI mainly employed domain-specific models, and GANs achieved remarkable breakthroughs in image generation and processing in the field of computer vision, thus laying the technological foundation for AIGC [22]. After 2022, general-purpose generation technologies, represented by large language models, witnessed revolutionary advancements, enabling AIGC to transition from single-modal generation to multimodal creative integration. Scholars like Miao Qinghai have noted that generative AI based on large models has advanced from basic intelligence to general intelligence, achieving qualitative improvements in text, image, and audio generation capabilities, which are redefining the traditional paradigms of knowledge production and content creation [9]. Simultaneously, domestic academia has focused on exploring

AIGC applications in specialized fields. Researchers, including Li Juan, have systematically defined the auxiliary methods of generative AI in cultural and creative design, demonstrating that AIGC can effectively optimize the content production processes in the creative industry [11].

2.3 The Relationship between AIGC and Intangible Cultural Heritage

The advent of artificial intelligence technology has shifted the preservation of intangible cultural heritage (ICH) from digital documentation to intelligent support. Traditional AI applications in the realm of ICH have predominantly focused on unidirectional technical assistance. For instance, computer vision has been employed for the detection of defects in cultural artifacts [22], and convolutional neural networks have been utilized for accurate pattern recognition [23]. These technological advancements have significantly improved the efficiency and precision of digitalization endeavors. However, their application is still confined to passive protection, merely performing pre-defined tasks without enabling the creative reinterpretation of cultural elements. This approach fails to effectively tackle the long-standing challenge in the preservation of intangible cultural heritage (ICH), namely, the situation where preservation is relatively easy while innovation is arduous.

The emergence of generative artificial intelligence (AIGC) technology has offered transformative opportunities for the conservation and innovation of intangible cultural heritage (ICH). Since the introduction of Generative Adversarial Networks (GAN) in 2014, the advancement of deep-learning algorithms and computing capabilities has propelled AIGC from experimental prototypes to functional tools. This development has notably improved the quality and efficiency of content generation, leading ICH protection into a new era characterized by active creation. The LoRA-style model developed for blue jacquard dyeing techniques not only performs digital archiving of traditional patterns but also generates new designs in line with contemporary aesthetics [23]. This allows this endangered craft to achieve modern expression through digital genetic recombination. By utilizing 3D generation technologies such as Gaussian Splatting [24], AIGC can construct immersive virtual environments, extending traditional architectural craftsmanship from museum exhibitions to virtual realms. Users can adjust parameters in real-time to explore regional style combinations, thus converting the experience of ICH from passive viewing to interactive and creative engagement [25-26]. Furthermore, multi-agent collaborative AIGC systems [23] further lower the participation barriers. Platforms like EnamelAI Painter assist non-professionals in understanding the logic of Guangcai porcelain glaze color matching, thereby establishing a dual-driven model of professional inheritance and mass dissemination.

From a macro perspective on cultural heritage preservation, AIGC has established a virtuous cycle mechanism for intangible cultural heritage (ICH) ecosystems. Guided by the principles of cultural ecology, AIGC intelligently translates the cultural DNA of ICH elements and feeds the generated results back into a digital cultural repository for redesign [27]. This process creates a self-reinforcing closed-loop system. The model not only ensures the continuity of ICH's cultural essence but also stimulates innovative vitality through technological means, thereby achieving a sustainable development

framework in which heritage is both preserved and innovated.

3. The Core Difficulties In The Inheritance And Protection Of Shu Brocade

3.1 Limitations of the Traditional Master-Apprentice System

The apprenticeship system for traditional craftsmanship demands a substantial amount of time and physical exertion. Nevertheless, its reliance on oral and mental transmission results in inefficient skill dissemination. In China, the majority of intangible cultural heritage inheritors are of an advanced age, and numerous craftsmen are too old to effectively guide apprentices. Concurrently, the younger generations exhibit minimal interest in this domain, primarily due to the extended training durations and meager initial rewards, which may potentially result in transmission lacunae. Furthermore, with the evolution of aesthetic tendencies, traditional auspicious motifs, including the mythical birds of Bashu in Shu Brocade, renowned for their intricate and imposing visual styles, fail to captivate contemporary youth, thereby further intensifying the risk of generational discontinuity.

3.2 Practical Shortcomings of the College Education Model

To address the talent shortage, some institutions have integrated Shu Brocade techniques into their curricula with the goal of cultivating professionals at scale. Nonetheless, practical implementation encounters several challenges. First, there is an excessive focus on theory, which undermines hands-on practice. The curriculum primarily emphasizes theoretical subjects such as textile history and pattern analysis, resulting in inadequate practical training that prevents students from mastering essential weaving techniques. Second, training facilities are limited. The equipment required for Shu Brocade weaving is both costly and space-intensive, and most institutions lack dedicated workshops or comprehensive sets of machinery, thereby depriving students of authentic weaving experiences. Third, the positioning of the curriculum remains unclear. Some institutions offer Shu Brocade-related content solely as general elective courses, providing superficial instruction that fails to systematically convey the craft.

3.3 The Structural Deficiency of the Double Teacher Team

The scarcity of dual-qualified instructors represents a substantial impediment to the educational quality within Shu Brocade institutions. Seasoned Shu Brocade artisans are endowed with considerable technical proficiency. Nevertheless, they frequently lack systematic pedagogical theories and teaching methods, which renders the conversion of their practical experience into standardized classroom content arduous. In contrast, university faculty members, despite being well-acquainted with educational theories, generally lack practical experience in Shu Brocade weaving. Their limited comprehension of the craft is insufficient to provide students with precise practical guidance. This disparity between artisans who are unable to teach effectively and teachers who are unable to practice competently severely undermines the institutional dissemination of Shu Brocade techniques.

3.4 The Absence of Cultivation of Cultural Identity

The preservation of Shu Brocade craftsmanship extends beyond the mere transmission of techniques; it must be rooted in cultural identity, which serves as its spiritual foundation. However, current educational practices exhibit significant deficiencies in promoting Shu Brocade culture. In terms of audience engagement, its dissemination is largely restricted to students majoring in textile and intangible cultural heritage (ICH), lacking a comprehensive outreach strategy. At the primary and secondary education levels, there is a notable absence of systematic instruction regarding local ICH, Shu Brocade, which results in a limited understanding among younger generations. Furthermore, universities offer few cultural events, academic lectures, or physical exhibitions centered on Shu Brocade, thus failing to cultivate a dynamic cultural heritage environment. This disconnect in cultural identity leaves students with only rudimentary skills and insufficient commitment to preserving ICH, thereby exacerbating the issue of talent attrition.

4. The Core Path of AIGC: Empowering the Protection and Inheritance of Shu Brocade

4.1 Visual Expression Innovation: Reconstruction of Contemporary Communication Form of Shu Brocade Patterns

As a paradigmatic representative of textile intangible cultural heritage, the traditional dragon and Baoxiang flower patterns of Shu Brocade encounter constraints in modern fashion and cultural product applications owing to their visually intricate and cumbersome characteristics. Drawing on the AIGC dissemination model of indigo-dyed cloth [22], a three-dimensional approach for the visual innovation of Shu Brocade is proposed. Firstly, it is advocated to develop a specialized generation model for Shu Brocade patterns. By collaborating with inheritors of intangible cultural heritage, cultural scholars, and technical teams, core visual elements such as scrollwork, cloud patterns, and pearl-linked motifs are extracted. Through the application of LoRA technology for lightweight reconstruction and sub-model training, a modern reinterpretation of traditional patterns is achieved. Secondly, it is recommended to establish a semantic content matrix for pattern culture. Utilizing AI-generated narrative techniques, bilingual content integrating historical stories and contemporary interpretations is created for various Shu Brocade patterns. For instance, enhancing the Tang Dynasty weaving technique of Eight-Petal Halo Brocade with modern fashion design applications enhances the cultural communication value of the patterns. Then, expand scenario-based communication channels. By utilizing platforms such as short videos, virtual try-on, and digital collectibles, apply AIGC-generated Shu Brocade patterns to products like virtual clothing and cultural and creative merchandise, facilitating the transformation of Shu Brocade from cultural relics to everyday cultural symbols.

The achievement of this objective is underpinned by dual guarantees. Firstly, at the technical level, extant research data reveals that AIGC-generated intangible cultural heritage visual content can enhance young people's awareness of intangible cultural heritage by more than 40% [28], and the style transfer accuracy rate reaches as high as 98.45% [29], offering reliable technical support for the digital visual innovation of Shu Brocade. Secondly, at the communication level, the 2025 TikTok Intangible Cultural

Heritage Data Report shows that TikTok added over 200 million new videos related to national-level intangible cultural heritage in the past year, a year-on-year increase of 31%. The related short videos garnered 749.9 billion views, and 14 million netizens shared their intangible cultural heritage experiences. Among them, the number of AI-related intangible cultural heritage videos increased by 1,625%, indicating the vast market potential of integrating AIGC with scenario-based communication of intangible cultural heritage.

4.2 Skill Inheritance Upgrade: Achieving Digital Preservation and Efficient Teaching of Core Processes

The technical model for the recognition and digitization of Shu embroidery needlework via convolutional neural networks (CNN) [29] can be directly applied to the realm of Shu Brocade weaving. This practical implementation consists of three crucial elements. Firstly, the digital modeling of core techniques is carried out. Through the utilization of motion capture technology, the operational processes of the fundamental skills in Shu Brocade, specifically the continuous warp and broken weft techniques, are comprehensively recorded. Key parameters of weaving force, warp density, and weft transition angles are converted into digital models interpretable by AI, thus achieving the permanent digital preservation of these core techniques. Secondly, the generation of dynamic instructional content is enabled. By harnessing AIGC technology, visualized dynamic teaching videos and interactive courseware are developed based on the digitized skill models. This method vividly presents the weaving procedures related to various patterns, effectively overcoming the limitations of the traditional master-apprentice system, where skills are often tacitly understood but difficult to express precisely. Finally, an intelligent skill defect alert system is established. This AI-based craftsmanship verification system compares standard technical parameters with actual operational data, allowing for the real-time identification of process deviations and the formulation of optimal correction plans to improve the stability of inheritance quality. Existing research indicates that AI-assisted visual inspection technology can accurately detect craftsmanship defects in cultural heritage [22], while 3D generation technology facilitates the full-process digital replication of intangible cultural heritage techniques [25]. Collectively, these advancements offer a feasible technical approach for the permanent preservation and efficient inheritance of Shu Brocade craftsmanship.

4.3 IP Innovation and Development: Building a Market-oriented Transformation System for Shu Brocade Culture

The model of Hakka culture utilizing large language models for knowledge generation and dissemination [30] offers a technical paradigm for the development of Shu Brocade intellectual property (IP). On this basis, an AIGC-based innovation system for Shu Brocade IP can be established. Firstly, the intelligent deconstruction and reconstruction of cultural elements. Through AIGC, the cultural connotations of Shu Brocade patterns are deeply deconstructed, enabling the extraction of distinctive core visual symbols. These symbols are then reconstructed into design elements suitable for cultural and creative products and digital content, integrating modern design concepts.

Secondly, personalized cultural and creative solutions. By integrating user profile data, AIGC generates customized solutions for Shu Brocade cultural and creative products that are tailored to individual users. For example, it designs China - fashion style Shu Brocade phone cases for young consumers and custom Shu Brocade pattern scarves for the high - end market, thereby enhancing the market adaptability of the products. Finally, the expansion of new cultural content. AIGC generates new content forms such as digital collectibles, virtual clothing, and interactive narratives centered around Shu Brocade, which are connected with emerging scenarios like the metaverse and digital cultural tourism. This expands the monetization dimensions of Shu Brocade cultural IP. Existing research has verified that human-machine collaborative creation systems can effectively enhance the market acceptance of intangible cultural heritage cultural and creative products [23,28,31]. Meanwhile, AIGC's style transfer capability ensures the accuracy of cultural genes during the innovation process [32,33], assisting Shu Brocade IP in achieving the development goal of innovation while preserving its essence.

5. Conclusion

AIGC has evolved from a technological concept to a practical instrument for the conservation of intangible cultural heritage. Through the reconstruction of dissemination approaches, preservation paradigms, and innovation trajectories, it effectively tackles the fundamental issues related to traditional inheritance. In the context of Shu Brocade, a significant exemplar of textile intangible heritage, the implementation of existing AIGC practices, including innovating visual representations to expedite the dissemination of contemporary cultural symbols, digitally modeling techniques to guarantee the perpetual conservation of essential craftsmanship, and promoting IP-driven development to forge pathways for market transformation, enables not only the digital preservation of weaving techniques but also engages the younger demographic, thereby fortifying the inheritance foundation. This profound amalgamation of technological empowerment and cultural heritage propels Shu Brocade towards its primary goal of living inheritance and offers replicable models for the digital transformation of other traditional handicrafts.

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