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Research on the Integration and Innovative Application of Batik from the Miao Ethnic Group in Danzhai from the Perspective of the Metaverse

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Abstract: Digital technology has become an essential tool for promoting the inheritance and development of intangible cultural heritage. Danzhai Miao batik, recognized as a national- level intangible cultural heritage in China, demonstrates significant potential for digital application. This paper focuses on the challenges currently faced by Danzhai Miao batik in its development and explores how the characteristics of the Metaverse can offer innovative pathways for its digital transformation. Drawing on existing case studies of intangible cultural heritage digitization and Metaverse theory, this study analyzes the application scenarios that combine the technical features of the Metaverse with the unique cultural characteristics of Danzhai Miao batik. The findings indicate that the Metaverse presents a new opportunity for the digital preservation and dissemination of Danzhai Miao batik. It not only maintains the cultural core of its traditional dyeing techniques but also supports the continuation and revitalization of its cultural value.

1. Introduction

Danzhai Miao wax-resist dyeing can be summarized as a process of "wax application, dye resistance, and wax removal to reveal patterns." The primary steps involve first applying hot wax onto textiles using specialized tools to create designs, then dyeing the fabric, and finally removing the wax layer. During dyeing, the wax-covered areas resist the dye, resulting in patterns that contrast sharply with the dyed portions of the fabric. Danzhai Miao wax-dyeing features diverse styles and distinctive patterns that embody local characteristics Figure 1, setting it apart from wax-dyeing styles in other regions[1] . However, this traditional art form currently faces challenges in both inheritance and dissemination, which can be broadly categorized into three main areas.

Figure 1: Batik from the Miao Ethnic Group in Danzhai.

1.1. The natural physical limitations of the art form reduce its potential audience

From the perspective of current market demand, wax-dyed clothing faces certain inherent limitations. Its stiff texture and limited insulation make it less appealing to contemporary consumers. Additionally, traditional hand-dyeing techniques often use mineral and plant-based dyes, with the latter derived from plants like pagoda tree, turmeric, and gardenia. While these dyes are environmentally friendly, plant-based dyes are prone to fading and yield less vivid colors, affecting the product's durability and aesthetic appeal[2]. Consequently, addressing these physical limitations —whether by enhancing them or incorporating modern techniques to improve them—is crucial for expanding the market appeal of Danzhai Miao wax-resist dyeing.

1.2. Preconceived Preservation Approaches

Intangible cultural heritage embodies the memories and ideas from the height of cultural prosperity. However, current efforts to preserve intangible cultural heritage often follow a preconceived approach. While this method has yielded some success in protecting crafts like wax-resist dyeing, it has also exposed limitations. This traditional preservation model has led to issues of homogenization and imbalance in cultural resources.

Rapid industrialization over the past few decades has placed immense pressure on China's traditional heritage, weakening or even endangering many traditional crafts. Scholars strive to restore these traditional symbols to their original historical authenticity. However, the survival of intangible cultural heritage remains challenging in highly industrialized urban settings, primarily due to conflicts between traditional representations and contemporary contexts.

The preconceived preservation model often binds "ethnic" and "heritage" identities exclusively to the past, which limits deeper integration with modern society. By categorizing intangible heritage as strictly "traditional," this entrenched label presents considerable challenges for modernizing crafts like wax-resist dyeing. In essence, the transmission of intangible heritage is a human-centered, life-driven practice that thrives as "living heritage". Consequently, effective preservation requires moving beyond preconceived notions to embrace a people-centered, dynamic approach, enabling intangible heritage to evolve and grow within contemporary contexts[3] .

1.3. Homogenized Preservation Methods

The dissemination of dyeing techniques is relatively narrow in scope and scale, and preservation methods for various heritage projects often lack differentiation, tending toward homogeneity. Current methods primarily depend on face-to-face teaching by practitioners or dissemination through traditional media. Heritage transmission generally adopts a "backward-facing" model,

following a top-down approach that demands strict “mirror replication” of previous generations' skills, leading to highly codified transmission[4] . This homogeneity in preservation methods not only stifles innovation and limits adaptation to modern contexts but also restricts the display of diversity and uniqueness across different heritage projects. Effective preservation must emphasize differentiation, employing flexible transmission and dissemination strategies tailored to each project’s distinct characteristics, thereby breaking free from the constraints of homogeneity[5] .

This paper will explore how metaverse technologies can address these challenges, fostering the continued development of intangible heritage in a digital landscape. To unlock the metaverse’s innovative potential in heritage preservation, we must move beyond simply replicating tradition and instead deeply examine the current status and challenges of heritage transmission to identify optimal protection and preservation pathways. As a form of living heritage, Miao wax-resist dyeing represents not only historical and cultural legacy but also a dynamic tradition that adapts with time. The challenge today is to preserve the vitality of these cultural traits within modern society using innovative methods. With the rapid advancement of digital technology, integrating it with intangible cultural heritage has become a mainstream trend. Emerging metaverse technology offers immersive experiences and high-fidelity digital transformation, opening new possibilities for heritage preservation. This paper focuses on utilizing the immersive characteristics and technological capabilities of the metaverse to explore the recreation and transmission of Danzhai Miao wax-resist dyeing within the metaverse, examining how this innovative approach can infuse traditional culture with new vitality under the support of modern technology.

2. Metaverse Technology in the Analysis of Danzhai Miao Wax-Resist Dyeing

2.1. Definition of the Metaverse

The metaverse's evolution has been propelled by rapid advancements in virtual reality technology. Its operation and development rely on collaboration among multiple entities, interconnected through independent sensory devices, digital platforms, network infrastructures, and collaborative protocols. As a virtual space with a novel form of social organization, the metaverse is characterized by high fidelity, decentralization, multi-actor collaboration, and multi-sensory immersive experiences. With ongoing technological innovations, the metaverse is progressively extending into the realms of traditional cultural industries and intangible cultural heritage, offering new opportunities for digital empowerment[6] .

Within the metaverse’s deeply interactive environment, the core cultural values and mechanisms of intangible cultural heritage can be fully showcased, making it a promising platform for integrating digital technology with culture[7] . Through the media-driven interaction of virtual and real worlds, the metaverse is becoming a key trend in the preservation and transmission of intangible cultural heritage, enabling traditional culture to find renewed expression in the digital world[8] .

2.2. Theoretical Rationale for Metaverse Technology in the Digital Development and Preservation of Danzhai Miao Wax-Resist Dyeing

In the context of rapid technological advancement, the value of culture is increasingly amplified as society transitions from a post-industrial era to a knowledge economy, highlighting the significance of knowledge, experience, and culture. With greater material fulfillment, individuals are more inclined to seek spiritual and cultural enrichment, leading to a heightened interest in cultural resources and the revival of traditional crafts. This reflects the characteristics of a post-industrial society and is a practical manifestation of localized modernization.

Changes in material culture often reflect shifts in emotional and aesthetic values, where cultural products become more than just functional items—they serve as aggregators of symbolic and cultural capital. Handcrafted items carry warmth, uniqueness, and character, representing cultural attributes that shape a lifestyle infused with profound humanistic qualities[9] .

As demand for cultural artifacts grows, the need for digitization has emerged. There is immense potential for the visual development of Danzhai Miao wax-resist dyeing within the metaverse, which may even play a central role in shaping the visual symbol system of the metaverse in the future. By transcending traditional boundaries, refining wax-dyeing as a cultural symbol, and embedding it into the metaverse, new opportunities for its growth are created. For instance, in the early stages of metaverse development, virtual creative resources are relatively scarce, making the introduction of distinctive and culturally rich elements from the real world a unique advantage. This approach can establish a foundational aesthetic and promote broader dissemination.

Embedding intangible cultural heritage into the metaverse offers diverse possibilities and pathways for the digital development and preservation of Danzhai Miao wax-resist dyeing. The metaverse provides technological support for the protection and evolution of intangible heritage while also establishing a theoretical foundation for its transformation and development.

2.3. Technological Feasibility of the Metaverse in the Digital Development and Transmission of Danzhai Miao Wax-Resist Dyeing

The metaverse integrates various technologies, including virtual reality, big data, artificial intelligence, blockchain, and digital twin technology, enabling immersive experiences, cross-reality interactions, open editing, and decentralized transactions. This fusion allows for multilayered integration between virtual and real worlds across identity, social interaction, and economic systems. In the era of new media, applications carrying traditional crafts and intangible cultural heritage resources must continually innovate, materializing abstract concepts and diversifying formats so they can serve both as means for heritage transmission and as final digital products. Within the technology-driven metaverse, humanistic elements are amplified, making the introduction of traditional craft symbols as visual motifs more impactful, thus broadening their reach and enhancing audience engagement.

Embedding intangible cultural heritage in the metaverse provides new avenues and methods for heritage transmission, centering on digital technology. By dissolving the boundary between virtual and real, the "heritage interface" within the metaverse broadens dissemination pathways for intangible heritage. Supported by 5G, blockchain, brain-computer interfaces, virtual reality, digital twins, artificial intelligence, and cloud computing, the metaverse offers features such as decentralization, embodied interaction, immersive experiences, realistic content rendering, nonlinear interaction, and multi-terminal collaboration. The specific technical feasibility of this approach is reflected in several aspects:

2.3.1. Reduced Network Latency and Multi-Device Collaboration

With the support of 5G and cloud computing, network latency is significantly reduced, enabling collaborative creation across multiple devices. This feature overcomes the geographical and temporal limitations of Miao wax-resist dyeing, allowing for more convenient transmission of traditional skills and knowledge within the metaverse.

2.3.2. User-Generated Content (UGC)

In the metaverse era, solely relying on traditional designers cannot meet the high consumer demand, while the rise of user-generated content (UGC) brings considerable economic benefits and

broadens the methods for creating and sharing Miao wax-resist dyeing. This UGC model facilitates a broader dissemination and preservation of traditional crafts within a digital environment.

2.3.3. Overcoming Material and Production Cost Constraints

Due to the high cost of materials, intricate techniques, and lengthy production times, it is challenging for younger generations to fully engage with the art of Miao wax-resist dyeing. In the metaverse, however, material and time costs can be minimized, enabling the effortless creation of complex works that would require significant resources in reality. This reduces the learning and experiential barriers associated with the craft.

In the context of new technologies and media, leveraging the technical attributes of the metaverse makes the transmission and cultural promotion of Danzhai Miao wax-resist dyeing achievable. This approach explores digital applications empowered by the metaverse, rooted in the intersection of technology and culture.

2.4. Multi-Level Value Reconstruction of Traditional Dyeing Techniques Through Metaverse Technological Transformation

The value of traditional dyeing techniques can be reconstructed through a model that aligns with human perception and behavior, resulting in a three-tiered development model, as illustrated in Figure 2.

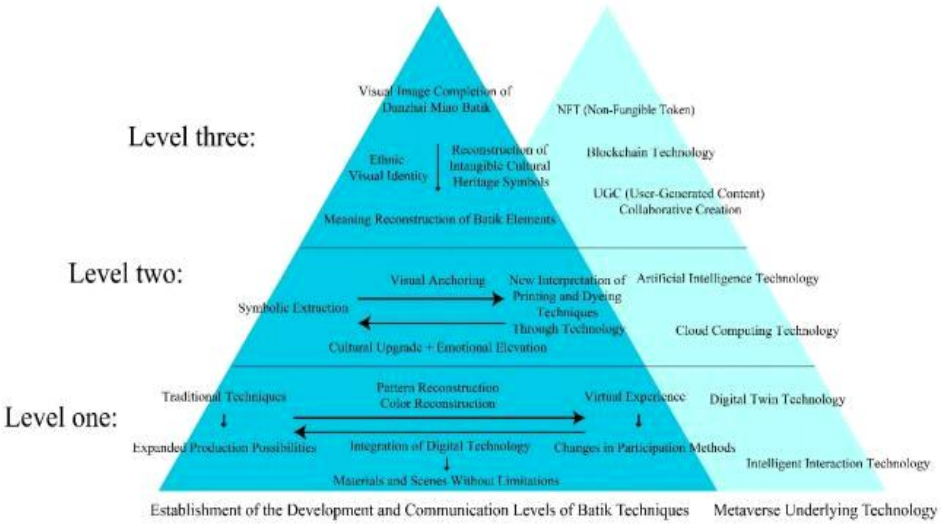

Figure 2: Developmental Levels of Integrating Wax-Resist Dyeing Techniques with the Metaverse.

2.4.1. Virtual Experience and Blending of Virtual and Reality

Traditional dyeing techniques face challenges in development and dissemination, primarily due to the limitations of current media, which rely heavily on text and images and struggle to convey the full texture and intricacies of dyeing craftsmanship. Existing digital dissemination methods, including physical museums, new media platforms, and e-commerce sites, have facilitated the popularization and economic valuation of intangible cultural heritage but remain limited to static visual information, which falls short of capturing the tactile quality of interactions between dyes and fabrics.

The immersive experiences enabled by the metaverse can address these limitations effectively. Through digital twin technology and AR/VR, dyeing techniques can be precisely replicated in the metaverse, allowing users to fully experience the texture of dyes and the details of the production

process. Unlike static forms of communication, these technologies offer multi-dimensional visualizations of the artistry and intricacy of dyeing, enhancing the visual appeal of textile patterns and colors.

2.4.2. Innovative Interpretations of Intangible Cultural Heritage through Technology

Industrialized dyeing has gradually standardized textile design, diminishing the unique charm of traditional craftsmanship and often causing visual fatigue. Virtual reality technology, however, offers new possibilities for the creation and dissemination of traditional dyeing techniques. By symbolically extracting traditional techniques, the metaverse preserves the cultural core while integrating modern media and creative technology, producing novel visual forms that breathe new life into intangible heritage. This fusion preserves the traditional essence of the craft while meeting the demands of modern communication.

In the metaverse, traditional dyeing's visual elements can be reimagined and diversely represented, transforming these symbols into popular cultural icons with tangible commercial value. Moreover, users can easily turn personal creativity into works of art via computer-aided tools, stimulating imaginative creation that both upgrades intangible heritage and fosters emotional connections with audiences.

2.4.3. Enhanced Visual Identity of Dyeing Techniques in a Virtual Context

At its core, the metaverse connects and creates by mirroring and interacting with the real world to form a new digital living space. Within this social framework, traditional dyeing art can evolve into a culturally significant visual symbol. The metaverse transcends time and space, allowing for free creation and open expression, thereby enhancing traditional dyeing techniques' visual identity and giving them a cohesive, influential digital presence.

The key to traditional cultural visual development lies in "recreating tradition," with technology as the underlying foundation within the metaverse, blending traditional elements into the digital environment. This new developmental model allows previously fragmented symbols to converge within the metaverse, granting traditional crafts new era-specific characteristics and visual identities. Consequently, dyeing techniques become not only symbolic representations within the metaverse but also integral parts of Chinese visual culture, fostering a fresh sphere of influence. This approach achieves the goal of "promoting the real through the virtual," enhancing the preservation and transmission of these traditional crafts.

3. Applications of Traditional Dyeing Craft Digital Products in the Metaverse

By examining existing digitized cases of intangible cultural heritage that exhibit certain metaverse technological characteristics, we can draw comparisons from typical scenarios and propose practical applications for promoting Danzhai Miao wax-resist dyeing in the metaverse to facilitate cultural dissemination and skill preservation.

3.1. Building a Platform to Enhance the Influence of the Dyeing Brand

The development of traditional dyeing techniques faces challenges in commercial application, currently limited primarily to product packaging design, which serves as a critical element in influencing sales with both aesthetic and informational value. In the metaverse, product marketing relies more heavily on the cultural narrative and symbolic expression. The cultural depth and unique patterns of traditional dyeing can serve as powerful elements of artistic design.

Creating an online platform with browsing and interactive features can significantly amplify the

reach of intangible cultural heritage. Once consumers develop a unified cultural recognition, dyeing art, as a brand's visual symbol, can gradually become a hallmark of the brand, reflecting its market positioning and establishing a distinctive design style. Furthermore, Danzhai Miao wax-resist dyeing could be applied to NFT fashion in the metaverse, integrating Chinese elements into fashion items to enhance aesthetic appeal and cultural resonance, thereby fostering consumer loyalty and emotional connection.

3.2. Expanding Creation Methods and Sales Channels for Heritage Products Through Virtual Technology

Virtual technology enables traditional dyeing techniques to explore diverse categories and effects beyond traditional physical forms. Virtual innovation not only preserves cultural elements of dyeing but also incorporates modern technology, allowing for a richer artistic expression. For instance, by reimagining traditional wax-resist composition through dynamic virtual reconstructions, designs become more vivid and enriched with cultural depth.

The iconic blue-and-white color scheme in traditional dyeing serves not only as a symbol of cultural heritage but also conveys unique cultural messages. In virtual fashion, traditional dyeing methods can be simulated to imbue digital clothing with the randomness and variability of hand-dyeing, displaying the natural gradients formed by dye interactions. When combined with representational and abstract patterns, this approach enhances the artwork's artistic and cultural value.

The inclusion of virtual technology also enhances consumer experience, imbuing the purchase of heritage-based items with an emotional energy that can translate into motivation for social engagement. This, in turn, reinforces users' identity within the heritage metaverse community, fostering both intangible heritage economics and social capital accumulation.

3.3. Completing the Visual Identity of Heritage in the Metaverse

By creating a heritage database, traditional wax-resist patterns can be blended with modern design concepts to generate unique artistic compositions tailored to user preferences[10] . With computer-aided design and digital algorithms, wax-resist patterns can be generated and optimized by deconstructing the relationship between images and meanings. These patterns can then be represented as arrays, enriching the diversity of designs and constructing a wax-resist vector pattern library. This extensive database provides a foundation for new creations and serves as a comprehensive visual identity system.

Based on this digital heritage database, digital analysis and educational resources can further promote research and academic exploration of intangible heritage, elevating its digital application value.

4. Conclusions

In the preservation and transmission of intangible cultural heritage, it is essential to consolidate traditional foundations while fully leveraging the advantages of emerging technologies. By creating immersive virtual environments centered around user experience, we can bridge the real world and the metaverse, exploring new possibilities for heritage development.

The opportunities for Danzhai Miao wax-resist dyeing in the metaverse are extensive, infusing products with renewed vitality and enhancing commercial value through the reimagining of traditional forms. The integration of the metaverse with heritage dissemination diversifies the creative avenues for Danzhai Miao wax-resist dyeing, providing users with a more refined,

immersive experience. This blend not only offers new development pathways but could also evolve into a commercial model. Beginning with virtual visual identities, this “virtual-to-real” approach offers novel possibilities for Danzhai Miao wax-resist dyeing in a digital context. Additionally, by refining the visual representation of intangible heritage, this approach holds immense potential to promote and celebrate the rich traditional culture of China.

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