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Research on the Digital Path of Live Inheritance of Tancheng Wooden Spinning Toys Driven by Immersive Experience

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Abstract

This study explores a digital pathway for the living heritage transmission of Tancheng wooden spinning toys driven by immersive experiences. Grounded in immersion theory, we construct a three-layer framework—"Cultural Translation, Interactive Participation, Perceptual Twin": The Cultural Layer employs semiotic approaches to translate regional cultural genes, distilling narrative symbols and dual-track experiential elements; The Interactive Layer leverages Unity/VR technologies to enable end-to-end user decision-making; The Perceptual Layer utilizes Blender modeling with AR/VR integration to construct multimodal scenarios. Aiming to establish a "Culture-Technology-Industry" closed loop through dual-track (online-offline) integration, future work will incorporate AI to excavate implicit cultural elements and develop replicable methodologies for modernizing intangible cultural heritage transmission.

Keywords

Immersive Experience, Inheritance of Intangible Cultural Heritage, Wooden Spinning Toys, Digital Translation

1. Introduction

Intangible cultural heritage (ICH) crafts face a crisis of intergenerational discontinuity in the digital era. As a national-level ICH, Tancheng wooden spinning toys confront limited audience engagement and restricted cultural dissemination due to their technical complexity and regionally embedded agrarian cultural roots. Current research predominantly focuses on technological preservation, lacking experiential approaches to living heritage transmission. This study proposes an immersive experience-driven framework addressing three dimensions: Theoreti-

cal Integration: Incorporating immersion theory to deconstruct relationships between cultural cognition and user behavior; Technological Synthesis: Combining VR/AR and digital twin technologies to construct phygital (physical + digital) scenarios.

Industrial Mechanism: Establishing a dual-track synergy mechanism bridging cultural preservation and industrial valorization.

Through this tripartite model, we enable a paradigm shift from static conservation to dynamic transmission of ICH, providing a replicable digital framework for analogous heritage projects.

2. Research Status of Digital Media Art and Living Inheritance of Intangible Cultural Heritage

2.1. Theoretical Framework of Immersive Experience and Its Application in Inheritance of Intangible Cultural Heritage

Immersion theory was first proposed by psychologist Csikszentmihalyi, who conducted a detailed study on the concept, triggering conditions, and nine dimensions of immersive experience. Immersive experience, that is, when people devote themselves to an activity, they will ignore the external environment and enter a state of "selflessness", which is also known as a deeper level of user experience (Fu, Xie, & Li, 2023). Immersive experience takes spatial, narrative, and social immersion as the core, and strengthens cultural cognition and memory through a sense of presence, flow, and multisensory stimulation, constructing a deep cultural perception scene. In the inheritance of ICH, immersive experience has significant advantages. Among them, spatial immersion builds a highly realistic virtual scene by constructing a highly restored ICH virtual scene using 3D modeling, VR, AR and other technologies, so that participants can feel as if they are in it and enhance the sense of spatial immersion. Xia Haibin and others used Unity3D technology, graphics algorithms and other technical means in the practical research on the application of VR technology in the display and protection of "ICH", and carried out virtual simulation of the overall technological process of traditional porcelain making in Jingdezhen, constructing a virtual simulation system of traditional porcelain making technology in Jingdezhen based on VR technology, so that experiencers can obtain an immersive experience similar to on-site porcelain making in the virtual environment (Xia, Liu & Zhang, 2022). Narrative immersion weaves the historical stories and inheritance process behind the ICH into an interactive plot through an engaging story line, and enhances the interaction between users and the virtual environment through multimodal interactive design, such as gesture recognition and voice interaction. Users unlock knowledge in the exploration, deepen the understanding of the value of ICH, stimulate emotional resonance of users, enhance participation, and achieve narrative immersion. Psychological researcher (Shin, 2018) found through research that the cognitive process of flow experience and presence will have an empathetic impact on individuals. Users experience the story framework constructed based on the cultural back-

ground of ICH as the main body, and can better substitute themselves into it, integrate their own experience with the emotions of the characters in the ICH culture story, and achieve resonance. Social immersion focuses on the interaction between users to enhance the social attribute of the experience. Liu Yixuan mentioned in the research on immersive social experience in the metaverse that through "cloud social interaction", immersive emotional interaction is carried out in virtual reality. In the virtual social environment, key shared experiences allow users to express their emotions in the process of participating in interaction and interact with other users, thus producing resonance and empathy (Liu, 2022). By building an online ICH community, it can promote the communication and sharing of enthusiasts, thus effectively promoting social immersion.

2.2. Research Status of Digital Technology Empowering Intangible Cultural Heritage

The research on digital technology empowering ICH has been evolving continuously. Early research focused on using digital technology to record and preserve ICH, such as establishing digital archives and databases to achieve permanent storage and convenient query of ICH materials. With the development of technology, the research has turned to using VR and AR technologies to enhance the display effect of ICH, bringing a new experience to the audience. At present, gamified and interactive design has become a research hotspot, aiming to improve user participation and communication effect. With the continuous integration and development of culture and art, art and technology, the immersive experience in digital media art has opened up a new path for the living inheritance of ICH. As a traditional handicraft, Tancheng wooden spinning toys integrate regional culture in shape. However, through field investigation and user interviews, it is found that there is a research gap in the digital inheritance and development of Tancheng wooden spinning toys (Shan, 2020), and many such ICH handicraft projects are in urgent need of digital technology empowerment in the inheritance dilemma . Taking Tancheng wooden spinning toys as the research object, this paper explores the digital path of ICH living inheritance driven by immersive experience, and further explores the balance point of technology and culture integration through VR, AR experience and online mobile application design, so as to provide effective inheritance strategies for ICH projects such as Tancheng wooden spinning toys, and promote the ICH to radiate new life in the digital age and achieve sustainable development. In the future, the research will be further deepened, the integration of technology and culture will be strengthened, and the integration of AI technology will be used to promote the sustainable inheritance and innovative development of ICH in the digital age.

3. Design Practice of Digital Living Inheritance of Tancheng Wooden Spinning Toys Driven by Immersive Experience

Based on rigorous field research, this study conducted in-depth interviews (lasting

20 - 40 minutes each) with core inheritors of Tancheng wooden spinning toys in Fannian Village and local young adults (n = 20, aged 18 - 35). The investigation revealed three distinctive challenges in the craft's transmission: Firstly, high risk of intergenerational discontinuity was observed, with core inheritors facing severe aging issues (averaging advanced age). Inheritor Fan Jimei noted scarce voluntary learners among youth due to low economic returns, lengthy training cycles, and shifting interests. Secondly, strong geographical limitations restrict its reach. The craft's visibility relies heavily on offline demonstrations and master-apprentice knowledge transfer, hindering access to broader audiences—particularly digital natives. Thirdly, ineffective transmission of tacit knowledge persists. Critical expertise—including force control during spinning, tactile experience, and material/color selection—resists comprehensive documentation through traditional text, images, or video. These empirical findings underscore the urgency for immersive digital technologies to revitalize the heritage transmission of Tancheng wooden spinning toys.

The core of ICH immersive experience design is to fully integrate and utilize ICH cultural resources and experience processes according to the characteristics of the target population (Mei, 2023). Based on the theory of immersive experience, this paper puts forward a set of design strategies with certain universality for the immersive experience design of ICH cultural inheritance, so that people can understand the deep cultural connotation of ICH in the interpretation of background stories, learn relevant technical knowledge in the challenge of ICH skills, feel the aesthetic characteristics of ICH in the unique environment layout, and spread ICH culture to experiencers from multiple dimensions. Through the design practice of digital living inheritance of Tancheng wooden spinning toys, the "Three-layer Strategy Model of Immersive Living Inheritance" (see **Figure 1**) is summed up and constructed—cultural translation layer, perceptual twin layer, and interactive participation layer. Cultural genes provide the creative basis, and through cultural translation, regional cultural genes are extracted to form a channel for technical realization and industrial linkage.

3.1. Cultural Layer: Digital Translation of Regional Genes

As an intangible cultural heritage, Tancheng wooden spinning toys have distinct regional cultural characteristics. In the design of immersive products, Su Shanying emphasizes that the design of immersive cultural and creative products should take cultural communication as the core task, and pay attention to two points: highlighting local culture and creating characteristic memory points (Su, 2024). Therefore, through in-depth interviews with inheritors and field investigations of the creative base, the cultural attributes of wooden spinning toys were systematically sorted out, and the core cultural genes such as patterns, shapes, and colors were digitally abstracted and redesigned from a semiotic perspective. Ensure that the design works have the unique local culture and characteristic memory points of wooden spinning toys.

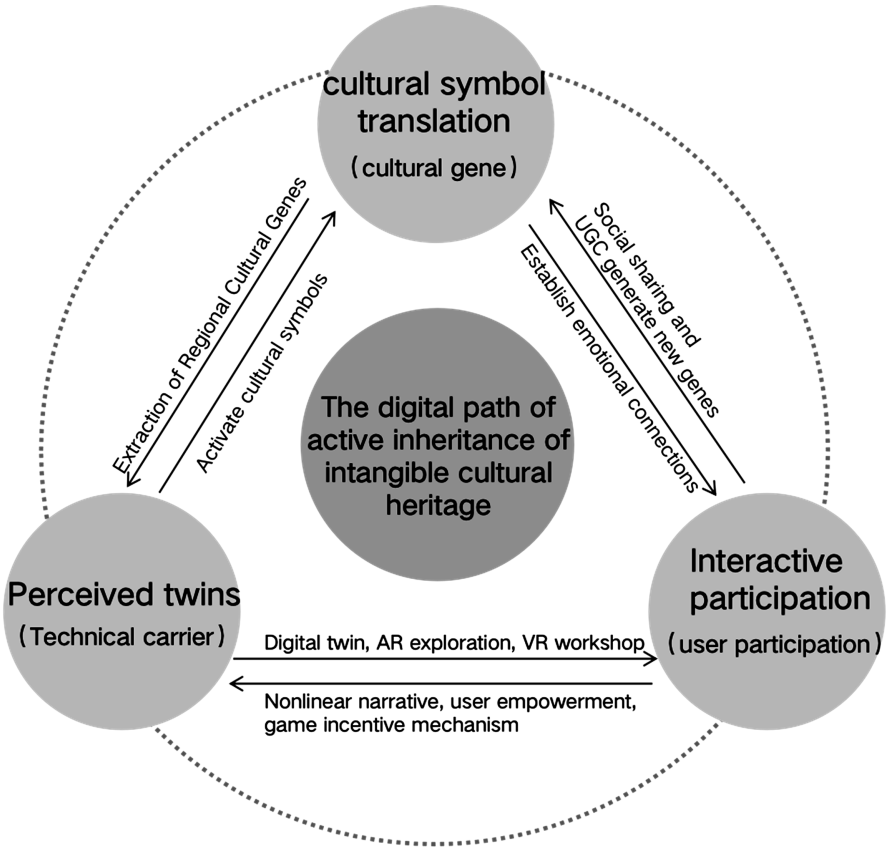

Figure 1. Three-layer strategy model for immersive inheritance.

In the UI visual design of "Spinning Wood", based on the local cultural characteristics of Tancheng wooden spinning toys, an elegant and simple color matching system that conforms to the intangible cultural heritage style is selected. Taking the wood color system as the base, typical toy colors (brown, beige, coffee, magenta, vermilion, orange, dark green) are integrated, and typical patterns are extracted. The wood grain material is symbolically processed to echo the connotation of farming culture and convey the warmth of handicrafts. As shown in Figure 2, the LOGO design of the APP focuses on the modern translation of traditional elements. The brushstroke characteristics of the carving knife, a tool for wooden spinning, are extracted to shape the character "Mu Xuan". This not only presents the solid texture of wooden products but also retains the cadence of the carving knife's brushstrokes. The poster design pushed by the APP continues the simple and unsophisticated texture of wooden spinning toys, with a wood texture background and a brown-coffee color scheme, creating a visual work that combines contemporary aesthetics with the charm of intangible cultural heritage.

Through the systematic extraction and translation of the cultural genes of ICH products, the symbolic immersion is improved at both the visual and cultural levels, a bridge of emotional connection between ICH culture and the audience is built, the cultural identity is strengthened, and the cultural connotation of the immersive experience is enriched from the deep dimension.

Figure 2. Design diagram of the logo and some interface posters.

3.2. Interactive Layer: User Empowerment and Participatory Narration

The core target user group for this project comprises urban cultural aficionados aged 18 - 45, who typically exhibit intermediate-to-advanced digital literacy and demonstrate interest in traditional culture despite limited substantive engagement opportunities, with a marked preference for interactive, experiential learning formats. Based on preliminary research, their primary needs center on engaging cultural knowledge acquisition, hands-on creative fulfillment, and personalized cultural product design/sharing—imperatives that directly informed the interactive layer's design philosophy: emphasizing user empowerment (e.g., autonomous material/process selection), participatory narrative (non-linear progression, creative freedom), and intuitive interfaces (iconic guidance, digital-natives-aligned interaction logic) to minimize technical barriers while ensuring immersive experience fluidity and sustained engagement.

In the dimension of human-computer interaction, with the collaboration of Unity engine and VR equipment, a non-linear narrative structure is adopted to fully stimulate the subjective initiative of users to participate in interactive behaviors. In the "Xuanmu" production module, users will initially face a selection interface of multiple series of wooden spinning toys and can screen among multiple exquisite single product series; after selecting the series and style, they enter the wood selection link, and users can independently select different materials to advance the production process. Subsequently, users will be in a virtual lathe scene, and through gesture recognition technology, they simulate the operation of the lathe and "personally" drive the lathe to cut the initial outline of the wooden spinning toy. At this time, users' operations will directly determine the shape of the work, breaking through the limitation of the system's preset shape, and significantly enhancing the sense of user empowerment. The system will guide users to complete the processes of sanding, priming, etc. in turn to prepare for subsequent

painting and coloring. In the stage of painting the wood embryo, users can fully release their creativity, draw unique patterns or lines on the surface of the wooden spinning toy, and independently select color combinations for painting. After completing the coloring, the components need to be assembled into a complete toy and given a personalized name. Finally, users can display their works in the digital display space and share creative experiences and fun with other users. In the "Xuanmu" APP, there are similar functions, as shown in **Figure 3**. This design mode in which users lead the whole process of type selection, spinning, painting, assembly, etc. breaks the passive acceptance mode of the traditional single linear narrative, and enhances the user's initiative and participation and strengthens the narrative immersion experience through deep empowerment (Wang & Yang, 2024).

Figure 3. UI display diagram of the production module.

3.3. Perceptual Layer: Multimodal Fusion and Digital Twin Construction

The design of the perceptual layer constructs a spatial scene with both immersion and physical realism through high-fidelity reproduction and multisensory stimulation, Note: The concept of "Perceptual Twin" proposed in this paper differs fundamentally from the more widely recognized "Digital Twin." Whereas Digital Twin emphasizes high-fidelity, full-element, real-time dynamic mapping of physical entities in virtual space—prioritizing data-driven system simulation—the Perceptual Twin focuses on leveraging digital technologies (e.g., high-precision modeling, AR/VR, multi-sensory feedback) to recreate at the user's sensory level (particularly visual, auditory, and tactile/kinesthetic) the core characteristics of intangible cultural heritage (ICH) objects—including their morphology, materiality, craft dynamics—and their cultural ambiance. Its core objective is to cultivate deeply immersive cultural experiences and cognition, rather than precise system emulation or real-time data synchronization. which is carried out from three aspects:

First, build a virtual-real integrated digital museum. Using 3D modeling technology, the Tancheng wooden spinning toys are accurately digitally modeled to

display their morphological structures in all directions and from multiple angles. In the early stage of digital collection and production, as shown in Figure 4, with the help of Blender high-precision modeling combined with SP material mapping technology, the digital modeling of wooden spinning toys is completed, and the natural wood grain texture and tool details are restored at the visual level, forming the basic digital twin assets of the digital museum, laying a technical foundation for the subsequent construction of the museum (Pang, 2022).

Figure 4. Some modeled digital assets.

Second, develop an AR real-scene exploration system. Based on the completed digital assets, an interactive product is created using AR technology. Users can scan the QR code on the poster through the mobile terminal, and with the help of the device's camera to identify the real-space plane, as shown in Figure 5, anchor the virtual 3D wooden spinning toy models (such as Gao bang ren, Ai bang ren, Hu tou chui, Journey to the West series, etc.) to the real scene, realizing the experience expansion of "ICH entering the daily space", and supporting lightweight interactive operations such as rotating, zooming, and moving the virtual model on the mobile terminal.

Figure 5. Schematic diagram of AR exploration operations.

Third, build a VR immersive workshop. Use the Unity engine to build a virtual production space for wooden spinning toys. Through the 3D modeling of equip-

ment such as lathes and tools, users are immersed in the virtual workshop environment. Through the head-mounted display camera, the user's hand movements and finger gestures are tracked in real time, the core technological processes such as spinning and painting are simulated, and the operational realism is improved through the hand gesture recognition technology in the virtual space, realizing the deep spatial immersive interactive experience.

4. Extraction of Design Strategies

4.1. Symbolic Extraction and Digital Translation of Regional Cultural Genes

From a semiotic perspective, a translation path of "cultural gene extraction-abstract reconstruction-scene implantation" is established. Through field investigation and in-depth interviews with inheritors, the core cultural elements of ICH handicrafts (such as the pattern, color, and shape symbols of Tancheng wooden spinning toys) are deconstructed, and abstracted using structuralist semiotic methods to form a cultural symbol system that can be digitally expressed. At the application level, the translated symbols are integrated into the design of the interactive system, such as building the UI visual tone with the typical color system of ICH (such as the brown coffee tone of wooden spinning toys), transforming traditional patterns (such as painting patterns) into dynamic interface elements and VI design extension elements, and reconstructing the LOGO design with the characteristics of craft tools (such as chisel brushstrokes). This semiotic-based translation strategy not only retains the cultural authenticity but also enhances the audience's cultural identity and emotional connection through modern design language, and is suitable for ICH categories with distinct visual symbol characteristics.

4.2. Integration of Participatory Narrative Design and Gamified Incentive Mechanism

Based on user empowerment, a non-linear narrative framework is constructed, and participatory creation is realized through multi-dimensional decision nodes (such as process type selection, material attribute configuration, and production process intervention). Taking the practice of Tancheng wooden spinning toys as an example, users can independently select the type of wood, drive the virtual lathe to form a personalized outline, and complete the creation of works through links such as painting pattern design and component assembly. In this process, gamified elements such as work naming, digital exhibition hall sharing, and creative achievement systems are embedded, transforming one-way cultural output into two-way interactive experience, effectively improving the user's subjective participation and cultural memory retention rate. This strategy deconstructs the linear production logic of traditional handicrafts and establishes a closed-loop mechanism of "selection-operation-feedback", which is suitable for various ICH skills with process characteristics.

4.3. Construction of Digital Twin and Multimodal Immersive Experience System

Relying on the theory and technology of digital twin, a technical system of "high-precision modeling-multi-terminal interaction-sensory reproduction" is constructed. First, use 3D modeling tools (such as Blender) to carry out 1:1 digital reproduction of ICH handicrafts, restore material texture (such as wood texture) and process details (such as tool marks), and form a reusable digital asset library; second, use AR technology to anchor the virtual model to the real space, and users can realize lightweight interactions such as rotating and zooming the model through the mobile terminal, breaking through the limitation of physical display space; finally, build an immersive workshop based on the VR engine, and simulate the operation of core processes through motion capture technology (such as hand gesture recognition), realizing the multimodal fusion of vision, touch, and operation. Through the virtual-real mapping and sensory compensation mechanism, this system constructs an experience scene with both physical realism and cultural immersion, especially suitable for ICH projects that require space operation and process simulation.

4.4. Construction of Industrial Linkage Network and Dual-Track Experience Strategy

In the design of the experience model, a dual-track mechanism of "online digital ecology + offline physical workshop" is implemented. Online, immersive creation and cultural communication scenes are provided through digital platforms (such as VR workshops and AR interactive experiences), and offline, process hands-on practice and cultural experience are carried out relying on ICH inheritance bases, forming a closed-loop experience of "virtual cognition-physical practice". This model unites ICH inheritors, digital technology enterprises, and cultural institutions to form an industry-research alliance, and realizes the full-chain integration from cultural protection, technological innovation, to industrial development by opening up the context of cultural protection, technological innovation, and industrial development. It provides a sustainable commercial path for the transformation of ICH from static preservation to living inheritance, and is suitable for ICH projects with industrialization potential.

5. Summary and Prospect

This study takes Tancheng wooden spinning toys as the breakthrough point, deeply integrates modern digital technology, and constructs an immersive digital inheritance system. In the interactive experience, with the help of non-linear narrative and gesture recognition technology, users can independently control all links of toy creation and become the protagonist of the inheritance process; in the perceptual presentation, through high-precision modeling, AR real scene, and VR motion capture, the virtual and the real are skillfully integrated to bring users a multi-dimensional vivid experience; in the cultural expression, the cultural genes of

wooden spinning toys are deeply analyzed, and traditional elements are naturally integrated into modern design, building an emotional bridge between traditional culture and the audience and deepening people's cultural identity of ICH.

Quantitative assessment of user engagement and educational outcomes constitutes a critical next-phase objective for this research, with the current design practice establishing foundations for systematic user experience testing—including presence questionnaires, flow state assessments, pre/post cultural knowledge evaluations, and task completion analysis—where representative user cohorts will be recruited for rigorous experimentation to empirically validate platform efficacy and drive iterative optimization. While progressing through the design implementation, we recognize persistent constraints in technical accessibility barriers (notably acquisition/maintenance costs of high-performance VR headsets and supporting PCs coupled with user technical adaptability demands) and interaction fidelity limitations (specifically precision gaps in gesture recognition during delicate woodworking simulations and insufficient haptic force feedback compromising high-fidelity craft immersion). Consequently, future technical exploration prioritizes monitoring standalone HMD advancements for cost reduction, developing computer vision-driven interactions for enhanced precision, and integrating wearable haptic devices to optimize universal accessibility and inclusive design. Of course, we will actively attempt to apply AI and multi-sensory feedback technologies to bring users a smoother and more realistic experience. In the field of cultural exploration, we will further cooperate with inheritors to transform more implicit intangible cultural heritage connotations into perceivable digital symbols. In the direction of industrial development, we will focus on creating a complete business closed loop of "digital experience + physical derivatives" to achieve the sustainable development of the living inheritance of intangible cultural heritage. In addition, we will also extract universal methods and adjust them according to the characteristics of different intangible cultural heritage projects such as embroidery and pottery, helping intangible cultural heritage culture to transcend geographical restrictions and complete its modern transformation.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

Fu, Y. X., Xie, J. N., & Li, Z. X. (2023). Research on Immersive Interactive Experience De-

sign of Intangible Cultural Heritage Digital Platform. *Industrial Design, 5,* 108-111.

Liu, Y. X. (2022). Self-Reconstruction and Social Experience of Virtual Images in Cultural Communities under "Interactive Immersion". *Youth Journalist, 24,* 110-112. https://doi.org/10.15997/j.cnki.qnjz.2022.24.023

Mei, Q. R. (2023). Research on Immersive Experience Design of Intangible Cultural Heritage Based on Flow Experience Theory. *Footwear Technology and Design, 3,* 158-161.

Pang, C. Y. (2022). *Research on Interactive Narrative under Museum Digital Guidance*. University of Science and Technology Liaoning. https://doi.org/10.26923/d.cnki.gasgc.2022.000557

Shan, X. L. (2020). Research on the Inheritance Problem of Tancheng Wooden Spinning Toys in Southern Shandong. *Beauty and Times (Upper), 5,* 53-54. https://doi.org/10.16129/j.cnki.mysds.2020.05.018

Shin, D. (2018). Empathy and Embodied Experience in Virtual Environment: To What Extent Can Virtual Reality Stimulate Empathy and Embodied Experience? *Computers in Human Behavior, 78,* 64-73. https://doi.org/10.1016/j.chb.2017.09.012

Su, S. Y. (2024). Research on Design Strategies of Cultural and Creative Products Based on Immersive Experience. *Packaging Engineering, 45,* 85-96. https://doi.org/10.19554/j.cnki.1001-3563.2024.14.009

Wang, Z. K., & Yang, Q. (2024). Application and Exploration of Interactive Narrative in the Design of Intangible Cultural Heritage Digital Museum. *Design, 37,* 64-67. https://doi.org/10.20055/j.cnki.1003-0069.001529

Xia, H. B., Liu, D., & Zhang, Y. (2024). Practical Research on the Application of VR Technology in the Display and Protection of "Intangible Cultural Heritage"—Taking the Simulation of Traditional Porcelain Making Technology in Jingdezhen as an Example. *Decoration, 10,* 130-132. https://doi.org/10.16272/j.cnki.cn11-1392/j.2024.10.012