

Technology Empowerment and Field Reconstruction: Research on the Production Mechanism of Qiaoxiang ICH "Digital Twin" Space from the Perspective of Generative AI

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Abstract: In the era of transition from digital technology to intelligence, Generative Artificial Intelligence (AIGC) is reshaping the existence and communication logic of cultural heritage. As a unique diasporic cultural space in China, Jiangmen Qiaoxiang (hometown of overseas Chinese) faces the decline of its physical field and the rupture of intergenerational memory regarding its Intangible Cultural Heritage (ICH). Traditional digital protection often stops at static "mirror replication," failing to respond to the needs of living inheritance across time, space, and cultures. Drawing on Henri Lefebvre's theory of the production of space and Pierre Bourdieu's field theory, this paper proposes the concept of "Cultural Digital Twin" and explores how Generative AI drives the ontological leap of Qiaoxiang ICH from physical space to digital twin space. The study finds that AIGC produces a digital field of virtual-real symbiosis and dynamic evolution through three mechanisms: "algorithmic reconstruction of representations of space," "embodied simulation of representational spaces," and "interactive co-creation of spatial practice." This process not only achieves the digital proliferation of ICH resources but also triggers the restructuring of power structures and the transformation of capital forms within the Qiaoxiang cultural field. The paper further constructs a digital twin space production model based on "human-machine collaboration" and critically examines issues of technological ethics, algorithmic bias, and digital sovereignty, aiming to provide theoretical interpretation and practical paths for the revival of Qiaoxiang culture in the intelligent age.

Keywords: Generative AI, Digital Twin, Production of Space, Field Reconstruction, Qiaoxiang ICH, Living Inheritance.

1. Introduction: Diaspora, Rupture, and the Possibility of Digital Bridging

1.1. Origin of the Problem: The Spatio-Temporal Dilemma of Qiaoxiang Culture

"Qiaoxiang" is not merely a geographical concept but a cultural space constructed by mobility, diaspora, and return. Jiangmen, known as the "First Qiaoxiang of China," possesses unique Intangible Cultural Heritage (hereinafter referred to as "ICH")—ranging from the architectural techniques of Kaiping Diaolou standing in the countryside to the "Silver Letters" (Qiaopi) traveling across oceans, and from Taishan Guangdong Music in sacrificial rituals to the processing of dried tangerine peel on family dining tables. These constitute the spiritual bond connecting overseas Chinese of Wuyi origin worldwide. However, under the dual pressure of deep globalization and the flux of modernity, the inheritance of Qiaoxiang ICH is encountering a severe "spatio-temporal dilemma."

On the one hand, with the acceleration of urbanization, traditional clan villages are becoming increasingly hollowed out. The physical field on which ICH relies is shrinking, leading to an ecological crisis where "the skin no longer exists, so the hair has nothing to attach to." On the other hand, for the vast new generation of the Chinese Diaspora, the hometown has degenerated from concrete sensory experience to an abstract geographical symbol. The obstruction of

physical distance leads to the rupture of cultural memory and the alienation of emotional bonds. How to span physical time and space and rebuild a "presence" space capable of accommodating global Chinese has become an urgent proposition for Qiaoxiang ICH protection.

1.2. Technological Turn: From "Digital Archive" to "Generative Twin"

For a long time, the digital protection of ICH has mainly followed the logic of "rescue recording," establishing "digital archives" through audio recording, video recording, and 3D scanning. This mode is essentially a static "mapping" of physical entities. While it solves the problem of "preservation," it is difficult to solve the problems of "activation" and "presence." Archives are cold and closed, unable to generate interaction based on bodily perception.

Since 2022, the explosion of Generative Artificial Intelligence (AIGC) technologies represented by ChatGPT, Midjourney, and Sora has brought ontological innovation to the digital survival of cultural heritage. Unlike traditional Web 2.0 technologies, AIGC possesses human-like cognitive capabilities of "understanding-reasoning-generating" and multimodal interaction capabilities. It is no longer just replicating reality but is capable of "generating" reality based on massive data. When AIGC is deeply integrated with Digital Twin technology, a brand new "Cultural Digital Twin Space" emerges. In this space, the Diaolou is not just a viewable 3D model but a historical witness capable of dialogue; the Qiaopi is not just a readable image but a

narration of hometown accents capable of being heard.

This paper aims to explore how Generative AI intervenes in the protection practice of Qiaoxiang ICH and, from the perspective of spatial sociology, analyze how this technology produces a new "Digital Twin Space" and how this new space reconstructs the inheritance field of Qiaoxiang culture. This is not only a study of technological application but also a theoretical response to the cultural production mechanism in the intelligent age.

2. Theoretical Horizon: Production of Space and Cultural Digital Twins

2.1. Lefebvre's "Spatial Triad" Dialectics

French Marxist philosopher Henri Lefebvre proposed the famous "Spatial Triad" dialectics in *The Production of Space*, arguing that space is not a natural container but a social product. He divided space into three dimensions:

Spatial Practice: Refers to the perceived space, i.e., the process of social production and reproduction and its spatial characteristics.

Representations of Space: Refers to the conceived space, i.e., the abstract space constructed by scientists, planners, and technocrats through symbols and codes.

Representational Spaces (Spaces of Representation): Refers to the lived space, i.e., the symbolic space to which users attach meaning through imagination, memory, and emotional experience [1].

This theoretical framework provides a powerful tool for analyzing the ICH digital space constructed by AIGC. In the AI perspective, "Digital Twin" is not only a mirror image of physical entities (Spatial Practice) but also a rule system constructed by algorithms and codes (Representations of Space), ultimately aiming to provide users with immersive emotional experiences (Representational Spaces).

2.2. From Industrial Twin to Cultural Twin: Conceptual Shift

The concept of "Digital Twin" originated in the field of industrial manufacturing, referring to the dynamic mapping of physical entities in virtual space throughout their lifecycle. After being introduced into the field of cultural heritage, its connotation has undergone a qualitative shift. "Qiaoxiang ICH Digital Twin" does not pursue industrial-level physical parameter precision but pursues "fidelity of cultural logic" and "resonance of emotional experience."

The intervention of Generative AI allows "Cultural Twin" to transcend the limitations of static modeling, possessing "self-growth" and "interactivity." The digital twin space driven by AI is an "organism" that can generate content in real-time based on user interaction and constantly improve itself with the supplementation of historical data. This is a "fluid space" generated based on algorithms, which builds a transnational "Digital Hometown" for dispersed ethnic groups through the "deterritorialization" of Qiaoxiang physical space and the "reterritorialization" of digital space.

3. Mechanism Deconstruction: The Production Logic of ICH "Digital Twin" Space Driven by AIGC

Based on Lefebvre's theoretical framework, this study deconstructs the production mechanism of Generative AI intervening in Qiaoxiang ICH digital twin space into three

mutually supporting dimensions.

3.1. Conceived Space: Algorithmic Reconstruction and Semantic Encoding of Representations of Space

"Representations of Space" is the underlying logic and rule architecture of the digital twin space. In the AI era, this dimension is embodied in the deep learning and semantic encoding of ICH knowledge by algorithms.

Ontological Construction of ICH Knowledge Graph: Traditional ICH digitization consists of scattered "data points," while AIGC requires a structured "knowledge network." Utilizing Natural Language Processing (NLP) technology, AI can deeply mine Jiangmen's massive local gazetteers, genealogies, Qiaopi, and oral historical materials, extracting entities such as "people, places, times, events, objects" and their relationships, constructing a high-precision "Qiaoxiang Culture Knowledge Graph." This constitutes the "gene bank" of the digital twin space, ensuring the historical logic and authenticity of the generated space.

Generative Modeling and Scene Adaptation: Traditional 3D scene construction relies on manual modeling, which is costly and time-consuming. AIGC technologies (such as Neural Radiance Fields [NeRF], 3D Gaussian Splatting) can automatically deduce and generate large-scale 3D models of Qiaoxiang villages by analyzing a small number of historical photos or drone videos, and automatically fill in missing texture details. More importantly, AI can reconstruct space based on "semantic instructions." For example, by inputting "bustling Chikan Ancient Town in the 1920s" or "Diaolou scarred by bullet holes during the Anti-Japanese War," the AI model can automatically adjust the texture, lighting, and environmental atmosphere of the building to generate representations of space that conform to specific historical contexts. The essence of this capability is that the algorithm has mastered the "style grammar" of Qiaoxiang space.

3.2. Lived Space: Embodied Simulation and Affective Computing of Representational Spaces

"Representational Spaces" is the living field directly experienced by users and full of symbolic meaning. Through multimodal interaction technology, AIGC transforms cold digital models into "embodied places" full of emotional warmth.

AI NPCs and Historical Presence: A digital space without people is a ghost town. Intelligent NPCs (Non-Player Characters) driven by AIGC are the key to activating spatial vitality. "AI Natives" trained based on Large Language Models (LLM) possess independent personalities, memories, and dialect capabilities. When overseas Chinese enter the digital twin village wearing VR equipment, they no longer encounter robots that only repeat fixed lines, but "digital fellow villagers" who can chat in Taishan dialect, recount family pasts, and even engage in impromptu singing (Saltwater Songs). This anthropomorphic interaction greatly enhances the user's "Social Presence," making "returning home" a real emotional experience.

Generative Narrative of Multi-Sensory Channels: Qiaoxiang memory is not only visual but also auditory and olfactory. The multimodal generation capability of AIGC (Text-to-Audio/Video) can restore lost sensory memories. For example, in the digital twin Xinhui Dried Tangerine Peel

Village, AI can generate environmental sound effects (birdsong, wind) during the drying of tangerine peel based on weather data, and even simulate the aroma of tangerine peel through linked scent generators; in Diaolou defense scenes, AI can generate alarm sounds and gunfire in real-time. This full-sensory envelopment makes digital space a container for nostalgia, realizing the leap from "viewing" to "immersion" [2].

3.3. Perceived Space: Virtual-Real Interaction and Community Co-creation of Spatial Practice

"Spatial Practice" involves the way space is used and the reproduction of social relations. AIGC not only constructs space in the cloud but also reshapes the cultural practice of Qiaoxiang in reality through "virtual-real interaction."

Distributed Access and Decentralized Experience: Digital twin space breaks the geographical monopoly of ICH experience. Chinese teenagers in San Francisco or Vancouver can access Jiangmen's digital twin festival scenes (such as "Burning Tower" or "Piaose" parade) in real-time through mobile terminals or wearable devices. AI technology can also achieve real-time rendering of "Digital Avatars," allowing clansmen from all over the world to gather, worship ancestors, and interact in the same digital space-time with virtual images. This spatial practice completely changes the traditional geo-social model, forming a "Cloud Clan" based on cultural identity.

UGC+AIGC Community Co-construction Mechanism: The digital twin space should not be a static exhibition hall released unilaterally by officials, but a "digital pastoral" cultivated jointly by the community. AIGC tools lower the threshold for content production, encouraging overseas Chinese at home and abroad to upload old photos, letters, or oral recordings of their families. AI assists in repairing these fragmented memories and implants them into the corresponding geographical coordinates in the digital twin space. Every memory upload by a user enriches the details and depth of this space. This co-creation mechanism makes digital space a dynamic archive of collective memory, realizing a spatial practice landscape where "everyone is an inheritor."

4. Field Reconstruction: Capital Flow and Power Game in Digital Twin Space

French sociologist Pierre Bourdieu's "Field" theory emphasizes the configuration and struggle of capital (economic, cultural, social, symbolic) in specific social spaces [3]. The digital twin space constructed by Generative AI is not a utopia but a new field full of tension and power games.

4.1. Digital Transformation of Cultural Capital

In the traditional Qiaoxiang ICH field, Cultural Capital is mainly embodied in the unique skills and formulas mastered by inheritors, as well as genealogies and artifacts within families. These capitals are often embodied, private, and difficult to circulate.

In the digital twin field, the form of cultural capital has transformed:

Objectification of Embodied Capital: Inheritors' tacit knowledge (such as martial arts moves, cooking heat control)

is converted into standardized data models by motion capture and AI algorithms.

Virtualization of Objectified Capital: Physical artifacts (such as original Silver Letters) are converted into high-precision digital assets (NFTs).

This transformation gives cultural capital extremely strong liquidity and reproducibility. On the one hand, this promotes the dissemination and popularization of culture; on the other hand, it also triggers the loss of capital scarcity. When AI can infinitely generate perfect Diaolou murals, will the skills of traditional craftsmen depreciate? This is a political economy question worth pondering.

4.2. Cross-Domain Linking and Trust Reconstruction of Social Capital

The core of Qiaoxiang society is a strong relationship network based on blood and geography (Social Capital). With the replacement of immigrant generations, this offline network is becoming increasingly loose. The digital twin space reconstructs the way social capital links through algorithmic recommendation and virtual communities.

Strong Connection of Weak Ties: AI can intelligently recommend "digital clansmen" or "root-seeking partners" based on users' surnames, ancestral homes, or interest tags. This precise matching based on big data activates originally dormant weak ties and forms a new global Chinese social network.

Algorithmic Mediation of Trust Mechanisms: In traditional clan societies, trust is built on long-term face-to-face interaction. In the digital field, trust relies more on the transparency of algorithms and blockchain confirmation technology. AI-generated genealogy correction suggestions and AI identification of artifact authenticity are gradually becoming new sources of authority, marking the substitution and supplementation of traditional patriarchal authority by technological rationality.

4.3. Rebalancing of Power Structures: Who Defines "Reality"?

The field is an arena of power relations. In the production process of ICH digital twin space, there are multiple power games:

Technological Elite vs. Cultural Holders: Algorithm engineers hold the "code writing power" of the space, deciding the rendering style of the Diaolou and the dialogue logic of AI NPCs; while ICH inheritors hold the "cultural interpretation power." Without effective communication mechanisms, "technological hegemony" leading to cultural misreading (such as excessive gamification or spectacularization of Qiaoxiang architecture) is extremely likely.

Official Narrative vs. Folk Memory: AIGC has powerful data integration capabilities, but if training data relies excessively on official archives, it may obscure folk, marginal, and individual micro-memories. The construction of digital twin space should be wary of becoming a repeater of a single grand narrative and should instead become a "polyphonic space" where diverse voices coexist. AI should be empowered to excavate those forgotten corners of Silver Letters and restore the joys and sorrows of ordinary overseas Chinese, thereby achieving decentralized sinking of power.

5. Practical Path: Construction Strategies of Jiangmen Qiaoxiang ICH Digital Twin Space

Based on the above mechanism analysis and field scrutiny, this paper proposes specific construction paths for Qiaoxiang ICH digital twin space from the perspective of Generative AI.

5.1. Building "Fully Immersive and Interconnected" ICH Infrastructure

Establishing Jiangmen Qiaoxiang Culture Multimodal Large Model (Vertical LLM): Instead of simply relying on general GPT models, we should unite universities and technology enterprises to use Jiangmen's unique Qiaopi archives, dialect corpus, local gazetteers, and other data to train a specialized large model in the vertical field. This model should possess a high "Qiaoxiang Content," being proficient in Wuyi dialects and familiar with Qiaoxiang customs and historical allusions, serving as the "brain" of the digital twin space [4].

Creating a "Cloud-Edge-Device" Collaborative Computing Base: Utilize edge computing technology to reduce the latency for overseas users accessing the digital twin space, ensuring a smooth experience during high-precision 3D rendering and real-time AI dialogue, achieving "sensory-free access" globally.

5.2. Developing "Scene-based" Generative Application Paradigms

"Time Backtracking" System for Architectural Heritage: For Kaiping Diaolou and villages, develop a "Time Travel" application based on AIGC. Users can see not only the current status but also the brand-new appearance of the Diaolou when it was first built in the 1930s through AI-generated images, and even simulate defense scenes during the war. AI can automatically generate previews of restoration plans based on the damage traces of the building for reference by cultural heritage experts and the public.

"Seeing Words as Meeting Face-to-Face" System for Qiaopi Silver Letters: Utilize AI's OCR recognition and semantic understanding capabilities to digitally transcribe and translate illegible handwritten Qiaopi. Furthermore, use speech synthesis technology to simulate the writer's tone, reading the letter content in the hometown dialect, and generate a short video of the writing scenario. This is not only the digitization of documents but also the resurrection of emotions [5].

"Digital Apprentice" System for ICH Skills: Develop various AI-driven virtual teaching systems for skills such as Choy Li Fut and Maolong Brush making. AI can analyze the user's movement accuracy in real-time through computer vision and provide personalized guidance. At the same time, users can engage in virtual sparring with "Masters of Past Generations" generated by AI, experiencing skill inheritance across time and space.

5.3. Cultivating a "Symbiotic" Digital Cultural Ecosystem

Establishing Ethical Guidelines for "Human-Machine Collaboration": In the construction of digital twin space, the principle of "inheritor-led, AI-empowered" must be adhered to. Establish an ethical committee composed of ICH experts, inheritors, and technical personnel to conduct a "Cultural

Turing Test" on AI-generated content to prevent historical nihilism and cultural distortion.

Exploring DAO (Decentralized Autonomous Organization) Governance Mode: Encourage overseas Chinese of Jiangmen origin globally to participate in the governance of digital twin space through blockchain technology. Issue "Digital Villager IDs," allowing holders to participate in the formulation of space rules, planning of cultural activities, and distribution of digital asset proceeds. Through the sharing of interests and power, build the "Digital Twin Space" into a true "Spiritual Home for Global Overseas Chinese" [6].

6. Reflection and Conclusion: Technological Disenchantment and Humanistic Return

6.1. Ethical Cold Reflection: Algorithmic Bias and Digital Divide

While embracing the technological dividends brought by Generative AI, we must maintain a clear critical consciousness.

First is the issue of Algorithmic Bias. Existing mainstream text-to-image models are mostly trained based on Western aesthetic data, easily implanting stereotypes of "Orientalism" when generating Qiaoxiang architecture or clothing (such as rendering Lingnan architecture in Japanese style). Therefore, mastering autonomous and controllable training data and algorithm models is key to maintaining cultural security.

Second is the issue of the Digital Divide. Digital twin spaces that rely heavily on VR/AR equipment and high-speed networks may exclude the elderly population or overseas Chinese in underdeveloped areas. Technology should be inclusive; developing lightweight, low-threshold AIGC applications is a necessary measure to achieve cultural equity.

6.2. Conclusion

The Qiaoxiang ICH "Digital Twin" space from the perspective of Generative AI is not just a technological project but a profound socio-cultural experiment. Through the production of space and the reconstruction of the field, it attempts to anchor an eternal coordinate in fluid modernity and rebuild a hometown of presence in dispersed globalization.

The essence of this mechanism is to use technological rationality to warm humanistic emotions and use virtual codes to suture the cracks of reality. As Heidegger said, "dwelling poetically" [7]. In the intelligent age, we expect this digital twin space to become a new earth for global Wuyi overseas Chinese to "dwell poetically." Here, technology is no longer a cold tool but a bridge to the depths of memory; ICH is no longer an outdated remnant but a living body constantly growing and connecting the past and the future.

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