Construct Users' Digital Sense of Place Through Immersive Virtual Cultural Heritage -- Taking "Digital Intelligence Yuanjing Gulangyu" as an Example

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Abstract. Metacosmic technology provides the possibility for the survival of cultural heritage beyond physical time and space, but the current practice of digital cultural tourism often falls into the misunderstanding of "technical rationality overwhelms humanistic narrative", resulting in the lack of emotional thickness of the scene. This study takes "digital intelligence Yuanjing Gulangyu" as an example, constructs an analytical framework integrating "sense of place embodied cognition immersion theory", and deconstructs the generation logic of digital sense of place by comparing the interactive behavior of two groups of users with and without field experience. The study found that the formation of a digital sense of place follows the advanced path of "cognitive consensus, emotional resonance, co-creation identity". Field experience serves as a key "memory anchor", which can effectively transform visual stimulation into deep emotional immersion; However, due to the lack of real reference, pure virtual users are often trapped in surface Gamification interaction. Therefore, this paper proposes that it should go beyond the simple visual reproduction and turn to the narrative system of "meaning construction orientation", and solve the experience dilemma of "being in the heart but not in the mind" in digital cultural tourism by establishing the mechanism of CO creation of multiple subjects and deepening the design of embodied interaction.

Keywords: Digital Sense of Place, Memory Anchor, Embodied Cognition, Digital Twins, Gulangyu Islet

1. Introduction

In the process of cultural heritage transferring from physical entities to digital bits, metacosmic media promises to provide "embodied presence" beyond physical boundaries. However, looking at the existing digital cultural tourism projects, the exponential growth of technical accuracy has not been translated into the emotional attachment of users. Many scenes fall into the misunderstanding of technological determinism and are overly attached to the realistic restoration of the physical environment, but ignore the deep construction of the psychological meaning within the field. This digital field, which is separated from emotional ties, is difficult to stimulate Duan Yifu's

"Topophilia", leading to the bottleneck of "low user retention and weak emotional connection" for digital products [1].

Previous studies have mostly focused on rendering technology or single interaction design, but at the ontological level, the essential similarities and differences between digital and physical senses of place are still not systematically clarified. At the same time, few studies take "field experience" as a moderating variable to explore how it feeds back into the meaning generation of digital space. Qin Long pointed out that the core value of digital scenes lies in the embodied presence given by the depth of interaction, rather than staying at the physical level [2]. This study introduces the virtual reality perspective to explore the generation mechanism and influencing factors of digital sense of place, and provides a theoretical basis for the transformation of digital cultural heritage from "technology display" to "meaning construction".

2. Research method

2.1. Core concepts and theoretical basis

2.1.1. Local theory and digital sense of place

The sense of place in the physical world is usually intertwined with three dimensions: cognition, emotion, and identity. In this study, digital sense of place refers to the place attachment and meaning given by the user subject mapped in the virtual space through human-computer interaction and symbol interpretation. Unlike the direct sensory contact in physical space, the generation of a digital sense of place is more torturous. This study proposes that its generation path includes three levels: the first is the cognitive level. The cognitive level refers to the formation of users' cognitive consensus based on objects by realizing the accurate mapping and symbol recognition of the physical landscape in the virtual space; The second is emotional level, which evokes users' emotional resonance to the virtual scene by triggering human earth related events; Finally, the value level, based on the differences of individual memory precipitation, forms a deep co creation identity through interactive participation [3]. Compared with the physical sense of place, the digital field relies more on the positive construction of technology embodiment and user subjectivity.

2.1.2. Immersion theory and digital twins

In the context of cultural heritage, a digital twin refers to the high-fidelity digital reconstruction of physical cultural heritage using digital technology. Based on the immersion theory, this study believes that digital twins should not only stay in the replication of geometric models, but should be committed to building a cognitive transmission bridge between entities and virtual places. This includes three dimensions: situational simulation, perceptual reproduction, and interactive adaptation. Referring to Qin long's path hypothesis of "sensory stimulation - memory recall - emotional immersion" in VR experience and the "digital intelligence empowerment" model of Zhang Yanfei and others, this study believes that the "decentralized" nature of the meta universe makes digital twins have the potential to become an open platform for multiple subjects to jointly produce cultural significance [4].

2.1.3. Embodied cognition theory and virtual interactive practice

Embodied cognition theory emphasizes the core role of physical experience in cognitive construction [5]. Virtual interactive practice refers to the operation of interaction with clear goal

orientation in virtual space through an embodied and multimodal interactive interface. This study divides the interactive practice in the virtual environment into three dimensions, and corresponds to Zhou Kui's immersive communication framework [6]: open tour corresponds to "spatial practice" and confirms "virtual presence" through the movement of virtual avatar; Task based participation corresponds to "sensory experience", which triggers specific virtual practice through multimodal interaction; Immersive social networking corresponds to "identity" (such as cross dressing and home building), which enhances users' interaction in the community and sense of belonging through avatar customization.

2.2. Method design

This study uses the mixed research method, taking "digital intelligence Yuanjing Gulangyu" as a case, and explores the differences in user experience through interviews and comparative experiments. The research design focuses on the three dimensions of local construction, embodied practice, and immersion design. Through the logical closed loop of "case deconstruction interview verification theory refinement", it reveals the construction logic of the digital sense of place.

In terms of the selection of research objects, 20 participants were recruited by purposive sampling method and snowball sampling method, and were divided into two groups according to whether they had on-site experience: group A was pure virtual experience (12, no on-site visit experience in kulangsu), and group B was virtual and real experience (8, with on-site visit experience). The virtual interview recording screen is preferred for data collection, supplemented by Tencent conference online in-depth interview, to capture users' immediate reaction and deep feelings in the process of experience.

3. Difference and result

3.1. Feeling

By comparing the feedback of group A and group B, this part analyzes three aspects: the generation dimension of digital sense of place, the interactive feedback of embodied practice, and the depth of emotional immersion experience.

3.1.1. Spatial cognition: lack of visual dependence and embodied perception

At the cognitive construction level, the study observed an interesting paradox. Although the digital twin scene achieves high-precision reproduction visually, due to the lack of multisensory cues in the real environment, such as touch, body sensation, and spatial sound field, the sense of direction of most participants in the virtual space is significantly weakened. They often lose the ability to rely on their senses to determine the location in the real world, and have to rely heavily on the map guidance on the interface. However, this limitation of spatial perception does not completely damage the user experience, but brings "efficiency compensation" to some extent. Some group B users pointed out that the panoramic and intuitive information presentation method of virtual scenes effectively made up for their regrets caused by route planning errors in real tourism, and showed the unique advantages of digital media in information efficiency.

3.1.2. Embodied practice: the separation of identity and exploration motivation

Users' identity as "digital islanders" is obviously fragmented. Although the system endows users with virtual avatars, most Experiencers believe that this identity only stays in the visual representation and lacks the support of substantive social relations. Due to the lack of long-term online human interaction and in-depth role-playing mechanisms in the scene, the experience process shows a significant lack of social presence, that is, the "sense of single machine" generally fed back by users. However, in the non-linear open tour, the high degree of freedom design has stimulated users' desire to explore. Group A participants showed strong expectations for virtual natural landscapes (such as sunrise at sunlight rock), and this desire for exploration based on aesthetics constituted their initial motivation to confirm "virtual presence".

3.1.3. Emotional immersion: memory anchor and interaction interruption

Limited by the mobile carrier, the current immersive experience mainly depends on audio-visual channels. At the visual level, the high-fidelity restoration of the scene has been unanimously recognized by the two groups of users. Group B users can even evoke specific memories through specific visual symbols (such as roadside railings) (such as the scene of "Tuanjie ate ice four years ago"). At the interactive level, the experience is polarized: on the one hand, subtle interaction design (such as the horn sound triggered when blocking the road) can bring a strong sense of presence; On the other hand, repetitive mechanical tasks (such as a single AI old photo repair, clock in) and rigid time-space switching are easy to break the sense of immersion, leading to users' "playing".

3.2. Differences

Field experience plays a decisive regulatory role in the construction of a digital sense of place. The experience of group A (without field experience) mainly stays at the primary stage of "local cognition", focusing on the exploration of architectural aesthetics and technological novelty. Due to the lack of emotional memory, the "human earth connection" is relatively fragile. Once encountering technical faults (such as Caton and flash back), the weak link just established will break quickly, and it is very easy to form a negative first impression. For group A, the lack of interaction with social objects (such as changing clothes and the home) is regarded as a redundant function with low value.

In contrast, group B (with field experience) showed deeper emotional involvement. The on-the-spot memory has become a bridge connecting virtual reality and reality, enabling them to see the meaning behind the symbols on the screen, revealing nostalgic feelings frequently in interviews, and even specifically mentioning the companions who traveled together. They are more tolerant of virtual interaction and regard functions such as changing clothes as a means to enhance entertainment rather than a simple social tool. However, even for group B, due to the lack of an in-depth community interaction mechanism on the current platform, their experience still stops at "emotional resonance" and fails to move towards a higher level of "co-creation identity".

4. Discussion

4.1. Formation mechanism

4.1.1. The cornerstone of building a digital sense of place

The generation of a digital sense of place is not an overnight process, but a hierarchical and progressive process. Although digital twin technology can realize the visual handling of physical space, Duan Yifu's "love land complex" theory points out that the emotional hub is derived from the deep combination of aesthetic experience and memory precipitation, and the digital scene without the support of cultural core is just a pile of empty landscapes [1]. This study found that technical accuracy is only the premise of sensory activation, not the endpoint of meaning generation. For users, from landmark buildings to grass and trees along the road, they need cultural translation to become the "anchor" of serial memory, so that users' virtual browsing can be transformed from simple "viewing" to deep "aftertaste" and "dialogue".

4.1.2. Mutual construction of digital reproduction and memory to create "virtual presence"

Zhaozhenyu proposed that "technology embodiment is the basis of human-earth emotional connection in digital city" [7]. This study further confirmed that field memory played a key "catalyst" role in this process. When the virtual user changes from a simple viewer to a narrator who can identify specific scenic spots and recall relevant past events, the dialogue across time and space will be opened. The value of digital twins in heritage scenes lies in the continuous mutual construction of virtual space and user subject memory [8]. However, the study also found that it was difficult to maintain the long-term presence of users simply by relying on static cultural symbols. For example, although the "meta universe marathon" activity in the case tried, it failed to effectively transform into continuous user stickiness due to the lack of depth of publicity and interaction.

4.1.3. Interaction details determine the depth of emotional immersion

The simulation reproduction of rendering technology is important, but in this study, it is often the non-preset, passive micro interaction details (such as environmental sound effects, NPC random feedback) that really trigger the user's "flow" experience. These details shape the real "presence". As Qin Long said, emotional immersion needs the common construction of collective memory. The dual guidance of vision and hearing forms the basis of sensory immersion [9]. To realize the leap from sensory stimulation to emotional resonance, it is necessary to design interaction logic more in line with intuition and reduce the sense of alienation brought by technology itself.

4.2. Enlightenment and suggestions

According to Tian Ding&He Ying's strategy, unique geographical advantages and strong social attribute foundation, combined with Bai Xiaoqing's reference to the optimization scheme of the deep integration of space, cultural symbols, and text [10,11]. This study believes that promoting digital cultural tourism can transform from "watching" to "participating".

4.2.1. Build a multi-subject co-creation mechanism to strengthen user subjectivity

It should realize the leap from "emotional resonance" to "co-creation identity" and build a hierarchical co-creation platform. First of all, for mass users, the upload channel of cultural stories should be opened, allowing tourists to share their travel experience or tell folk tales by Aboriginal people, which can be implanted into NPC dialogue content after review, so as to enrich the humanistic thickness of the scene. Secondly, for professional groups, intangible cultural heritage inheritors or designers can be invited to participate in the in-depth iteration of scene content. Finally, it should establish a cultural inheritance incentive system to give high-quality content creators "digital cultural inheritors" certification or field rights and interests, and fundamentally solve the problem of users' lack of motivation to participate.

4.2.2. Design treasure seeking exploration path to stimulate willingness to participate actively

In view of the passive situation that users rely on map guidance, it is suggested to gamify the narrative logic. Taking advantage of the open map, the "treasure hunt" exploration task is designed to connect the scattered cultural attractions. The user triggers the corresponding task when entering a specific area, and can switch to the first-person perspective of historical figures for experience. This increases the passive reception of information during exploration and breaks the guiding thinking of linear narration.

4.2.3. Add differentiated plot mode to expand social and cultural depth

Customized experience mode shall be provided for different types of users. For group A (pure virtual Experiencers), the "Islander team leading mode" was developed to activate immersive social interaction through online reservation and real-time voice interaction; At the same time, the authority of personalized scene transformation is open (for example, the wishing bottle left on the beach can be seen by subsequent tourists) to enhance its sense of existence in the virtual space. For group B (experienced), design a "cultural gene puzzle solving task" that is strongly bound to the physical cultural heritage (such as decoding the organ code of the Bagua building to unlock the cultural origin of Kulangsu Music), expand the cultural depth, and avoid simple knowledge infusion.

5. Conclusion

In the development process of digital cultural tourism, space is no longer limited to the digital reproduction of physical sites, but is the core link deeply embedded in the narrative system of cultural heritage. This study shows that the formation of a digital sense of place is not a one-way projection of technology, but an advanced process following "cognitive consensus, emotional resonance co creation identity". To solve the dilemma of "shape like spirit" and "body in mind not in" in the current digital cultural tourism, the future spatial narrative can be optimized for the sense of experience according to the three principles of "cultural narrative priority, content adaptation according to people, and immersion determined by details".

The application of technology must serve the cultural translation, rather than the simple visual technology. By constructing a layered adaptive narrative framework and using lightweight multimodal interaction and AI dynamic adaptation technology, it can reduce the threshold of experience and realize the national sharing of cultural heritagld a cultural link of intergenerational transmission through the growth system of digital identity and the precipitation design of memory assets, so that digital space can truly become an important carrier for the living inheritance and

sustainable development of cultural heritage, and write a new form of cultural inheritance in the coexistence of virtual and real.

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