

Urban Renewal Practice Empowered by Smart Technology: With Sustainable Inheritance of Cultural Heritage as the Core

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ABSTRACT

Urban renewal is an important lever for promoting high-quality urban development, and the sustainable inheritance of cultural heritage is the core direction that urban renewal cannot deviate from. With the accelerated implementation of smart technology in urban governance, digital and intelligent means provide a new path to solve the pain points of cultural heritage protection in urban renewal. This article closely follows the cultural relic work policy of "protection first, rescue first; rational utilization, strengthen management", and analyzes the practical application of smart technology in cultural heritage resource survey, living inheritance, spatial restoration, revitalization and utilization, and public participation, based on publicly reported renovation practices such as Qingdao Dabao Island block and Beijing central axis. Research has found that smart technology can effectively balance the relationship between cultural heritage protection and urban functional upgrading, achieve the symbiosis of historical context continuation and modern urban development, and provide specific ideas for urban renewal practices in various regions.

KEYWORDS

Cultural Heritage; Urban Renewal; Smart Technology; Sustainable Inheritance; Sustainable Utilization.

1. INTRODUCTION

China's urban development has entered the stage of stock renewal from incremental expansion, and the focus of urban renewal has shifted from simple material space transformation to simultaneous improvement of cultural connotation and quality of life. In the "Opinions on Continuously Promoting Urban Renewal Action" issued by the General Office of the Communist Party of China Central Committee and the General Office of the State Council in 2023, it is explicitly stated that cultural heritage protection should be integrated throughout the entire process of urban renewal, and the cultural veins of the city should be firmly safeguarded. However, in the practice of traditional urban renewal, cultural heritage protection often encounters many practical difficulties: some old neighborhoods are renovated without even knowing the construction age of century old buildings, and the planning lacks solid basis; Some places still use the old methods of painting walls and repairing roofs, which are difficult to adapt to the needs of modern life; Some revitalization efforts rely solely on exhibitions, which cannot attract public participation, and some places even blindly demolish and rebuild without considering the value of heritage, leading to the rupture of urban memory.

The rise of smart technology provides a feasible path to solve these difficulties. Big data can help clarify the detailed background of cultural heritage resources, digital twins can accurately restore historical spaces, and AR/VR technology can truly bring intangible cultural heritage to life - these

technologies not only serve as a new tool, but also fundamentally reconstruct the logic of cultural heritage protection and inheritance [1]. This article focuses on the sustainable inheritance of cultural heritage, and combines real cases that have already been implemented in various regions to dissect the specific practical path of smart technology in urban renewal, explaining how technology can make cultural heritage both "retained" and "used well".

2. SMART TECHNOLOGY SUPPORTS PRECISE SURVEY AND FILING OF CULTURAL HERITAGE RESOURCES

The first step in protecting cultural heritage is to thoroughly understand the resource base - traditional surveys rely on manual measurement and handwritten records, which are not only slow but also prone to data omissions or errors, making it easy to encounter problems in subsequent planning. The digital census system built by intelligent technology can achieve precise identification, systematic archiving, and dynamic monitoring of cultural heritage resources, laying a solid foundation for urban renewal planning.

The digitalization work of Dunhuang Academy began in the 1990s. At that time, the technical team used high-precision scanning equipment to collect the colors, lines, and even subtle cracks of the Mogao Grottoes murals one by one, and stored the complete mural information in the digital database. Now this set of digital resources can not only be permanently saved, but also provide precise references for restoration personnel - for example, by digital comparison, the original color of which mural has faded can be known, avoiding errors in judgment based on experience during restoration. This approach was later applied to the National Cultural Relics Survey. Based on the results of the Third National Cultural Relics Survey, various regions used big data technology to build a graded and classified cultural heritage resource database, incorporating ancient buildings, sites, and intangible cultural heritage projects into management. This way, when planning urban renewal, it is possible to clearly know which areas cannot be moved and which areas can be optimized, avoiding the blindness of "starting construction without understanding the situation".

Dynamic monitoring is equally important. In the Beijing Central Axis Protection Project, the technical team has deployed sensors in the core heritage area to monitor the temperature, humidity, and structural stability of cultural relics and buildings in real time. Once the data exceeds the safe range, it will automatically alert [2]. They also built a digital twin model, which fully "moved" the physical space of the central axis onto a virtual platform [3]. Management personnel can see the real-time status of the heritage on the computer, such as which section of the city wall is at risk of weathering and which area may be affected by excessive pedestrian flow, and can take timely measures. This "census+monitoring" model has transformed the protection of cultural heritage from "repairing problems before they arise" to "prevention in advance", providing technical support for the principle of "protecting before updating" in urban renewal.

3. DIGITAL TWIN TECHNOLOGY ASSISTS IN THE OVERALL PROTECTION AND RESTORATION OF HISTORICAL SPACES

The value of urban cultural heritage lies not only in the value of individual buildings, but also in the historical spatial pattern and cultural atmosphere formed by these buildings. Traditional restoration often only focuses on repairing individual buildings, neglecting the overall appearance; Either for the sake of convenience, the old block can be demolished and rebuilt, resulting in a 'one-size-fits-all' homogenization. Digital twin and virtual restoration technology can achieve precise restoration of historical spaces while respecting authenticity, preserving the appearance and addressing practical living needs.

Qingdao Dabao Island block is the birthplace of modern commerce in Qingdao, where the "courtyard" buildings are distinctive - mostly in the shape of "mouth" or "field", with shops on the first floor and residential buildings on the upper floor, full of urban atmosphere. During the 2020 renovation, the technical team first used 3D laser scanning to scan the structure, door and window styles, and even the mottled marks on the walls of each courtyard into the computer, creating a digital twin model [4]. The team then tested different repair solutions on the virtual platform, such as sealing the courtyard in the middle of the courtyard to make an activity room. Would sealing the courtyard be feasible? Would adding elevators compromise the building structure? After testing, it was found that sealing the courtyard would affect ventilation, and adding elevators would require changing the load-bearing capacity. Finally, the plan of "retaining the layout+upgrading the interior" was determined - the exterior walls remained the same, the interior was relined with pipelines, bathrooms and heating equipment were added, and convenient service points were set up in the corners of the courtyard. After the renovation, the old residents did not move out, and the street flavor of the courtyard was not lost. Instead, it attracted many tourists to experience the life of old Qingdao (case source: Qingdao Municipal Bureau of Housing and Urban-Rural Development's 2022 "Report on the Protection and Renewal of Historical and Cultural Blocks").

The renovation of the Renfengli neighborhood in Yangzhou also adopted a similar approach. This block has a unique layout of alleys since the Tang and Song dynasties, with narrow alleys and mottled brick walls. Before the renovation, the technical team used digital simulation technology to test the impact of the height and color of newly built buildings in the surrounding area on the style of the neighborhood - for example, would a 10 story high-rise building next to it block the lighting of the alley? Would using red on the exterior walls conflict with the gray tone of the old neighborhood? Finally, it is stipulated that new buildings should not exceed 3 floors, and the exterior walls should be light gray to ensure that the new building blends with the old street area. This approach avoids the misconception of "demolishing the old and building the new", allowing historical spaces to meet the needs of modern life while preserving the original cultural atmosphere [5].

4. INTELLIGENT SCENE RECONSTRUCTION OF THE LIVING INHERITANCE SPACE OF ICH

ICH emphasizes "living inheritance", and there must be suitable scenes - for example, Lu embroidery needs workshops, and Ejiao (donkey-hide gelatin) production needs traditional workshops. If these spaces are squeezed out during urban renewal, ICH can easily be dated. Smart technology can transform ICH from "exhibits in museums" to "skills in daily life" by reconstructing inheritance scenarios and expanding dissemination channels.

When renovating the old city area of Jinan, a special space was left in the neighborhood to create an "ICH workshop": in the Lu Embroidery Workshop, inheritors can not only embroider on site, but also display the history of Lu embroidery through digital screens on the wall - from ancient palace embroidery to current cultural and creative design, visitors can scan the code to see; In the Ejiao Craft Inheritance Institute, the traditional steps of boiling glue are played in the form of animation, and the boiling process can also be simulated by AR equipment. Many children want to follow after experiencing it. This "physical space+digital experience" model makes ICH no longer an "antique", but a culture that can interact with modern people [6].

The "Digital Watchman" mini program developed by the Beijing Central Axis Protection Center is also very innovative. "Da Geng (night watch) is a traditional custom in old Beijing", and now it is combined with the dissemination of ICH through mini programs: users can open the mini program and follow the digital watchman to explore the central axis. When they reach a certain location, such as Zhengyangmen, relevant ICH introductions will pop up - such as how nearby time-honored brands make traditional pastries, and how folk artists perform Jingyun Dagu (a traditional narrative drum music). The mini program also sets up "ICH tasks", such as learning a simple Jingyun Dagu lyrics,

which can earn electronic badges after completion, attracting many young people to participate (case source: "Digital Practice Publicity of Central Axis Cultural Heritage Protection" by Beijing Municipal Bureau of Cultural Heritage in 2023). This approach breaks through the limitations of physical space, expands the scope of ICH dissemination, and encourages more people to understand and inherit ICH.

5. INNOVATIVE ACTIVATION AND FUNCTIONAL TRANSFORMATION OF CULTURAL HERITAGE EMPOWERED BY TECHNOLOGY

To achieve sustainable inheritance of cultural heritage, it is not enough to rely solely on "enclosing and protecting" it. It is also necessary to make it "live and use in the present" - "using to promote protection" is the path that can be taken in the long run. Smart technology can help cultural heritage connect with modern life needs, transform into practical new functions, and generate new value for old heritage, forming a virtuous cycle of "protecting well, using it, and then giving back to protection".

The revitalization of Qingdao courtyard is a particularly concrete example. After the renovation, the exterior walls of the courtyard were not painted in a bright and shiny manner, and still retained the original mottled wall skin, exuding the flavor of old Qingdao; At night, 3D Mapping technology is used on the walls to display old stories of Qingdao - from the lively atmosphere of merchants selling goods when the courtyard was just built, to the red memories of residents helping each other during the War of Resistance Against Japanese Aggression. Tourists can watch a "light and shadow show" standing in the courtyard. The interior of the building has been renovated to be more intimate, introducing a small format of "day tea and night wine". During the day, it sells local Qingdao seaweed buns and Laoshan tea, and at night it becomes a small tavern. Digital guide signs have also been installed, and old residents can tell stories by scanning the QR code [7]. A grandmother surnamed Zhang, who has resided there for sixty years, told stories about neighbors helping to take care of their children. Many tourists have been fascinated by it. This model of "old buildings+new formats+digital experiences" has made the courtyard a popular check-in spot for young people. With more people, the maintenance funds of the courtyard have also been secured, truly achieving a balance between protection and utilization.

The transformation of Beijing Shougang Industrial Park is more representative. This used to be a large steel plant, with tall blast furnaces and spacious factory buildings as solid industrial heritage. After it was shut down in 2010, it was a pity to demolish it, and it became a long-standing problem to keep it without knowing how to use it. Later, the team used intelligent technology to make an overall plan: the most prominent blast furnace was transformed into a ski jumping platform, which was used for the Beijing Winter Olympics and became a viral internet landmark; The old factory building has been converted into a creative park, and a smart operation system has been installed. With more tourists on weekends, the system relies on big data analysis to automatically extend the opening hours of the parking lot by 2 hours, and shops also adjust their business hours accordingly, making it convenient for tourists to visit; At the same time, using IoT technology to monitor the structural safety of industrial heritage, any subtle cracks can be detected in a timely manner [8]. The current Shougang Park not only showcases the ironclad atmosphere of the industrial era, but also offers skiing, cultural and creative shops. By 2023, it will receive over 5 million visitors (case source: Beijing Municipal Development and Reform Commission's 2023 "Shougang Park Transformation and Development Evaluation Report"), not only preserving its industrial heritage, but also revitalizing the surrounding catering and accommodation industries, boosting the regional economy.

6. BUILDING A SMART PLATFORM AND ESTABLISHING A MECHANISM FOR PUBLIC PARTICIPATION IN THE INHERITANCE OF CULTURAL HERITAGE

Urban renewal is aimed at improving the lives of residents. Cultural heritage protection does not only rely on the government and experts, but also requires the participation of residents - after all, residents are the living carriers of urban memory, and their opinions and practical participation directly affect whether cultural heritage can be passed down for a long time [9]. Smart technology can provide a convenient platform for participation, transforming the public from "watching from the sidelines" to "hands-on". The "Resident Council" on Gulangyu Island has undergone a digital upgrade. In the past, residents had to come to the venue to sit down and chat, and many residents who had to go to work or take care of their children couldn't find the time; Now through online platforms, residents can click on their phones at any time to view updated planning maps, write suggestions in the comment section, and participate in voting - such as whether to convert old villas into homestays, whether to keep old locust trees in the yard, and even elderly residents who work outside can speak remotely. In 2022, during the renovation of a certain area on Gulangyu Island, more than 300 valid opinions were collected in an online meeting. Suggestions such as "preserving the old banyan tree" and "adding accessible ramps" were all put into use. After the renovation, residents said that it had been "moved to the heart" (case source: Xiamen Municipal Bureau of Culture and Tourism's 2022 "Public Participation Report on the Protection of Gulangyu Historical Block"). This approach avoids the one-way decision-making where "the government has the final say", and the planning is also closer to the actual needs of residents. Beijing's "application-based lease termination" policy has also been improved through smart means. When renovating old neighborhoods such as Nanluoguxiang and Yandai Xiejie (Tobacco Pouch Slope Street), residents can apply for lease termination by opening the online system - those who want to move can check compensation standards and choose resettlement housing, while those who want to stay can submit their housing repair needs [10]. The system will also use big data to sort out residents' needs, such as which residents are older and need to install handrails, and which households with children need to optimize lighting. Some elderly people do not know how to use online systems, and the community even sends staff to come and help; During the renovation, residents watched the construction live. An aunt noticed that her windowsill waterproofing had not been considered for the rainy season and left a message on the spot. The construction team adjusted the plan on the same day. This model not only preserves the style of the old neighborhood, but also prevents residents from being relocated, avoiding the loss of urban memory.

7. CONCLUSION

The core of urban renewal is "people-oriented", and the core of cultural heritage inheritance is "continuation of context". The true value of smart technology is actually building a real bridge between these two - allowing urban renewal to not only improve the quality of life of residents, but also preserve the cultural memories left by our ancestors. From the Mogao Grottoes of Dunhuang using digital technology to retain mural colors, to Qingdao Dabao Island Block using digital twins to keep the civic charm of the courtyard (Liyuan), to Beijing Shougang Park using smart planning to make the old blast furnace a ski resort, these practical cases all show that smart technology is not used to show off, but really can solve problems - it makes heritage survey more accurate, repair more detailed, inheritance more alive, use more solid, participation more convenient, and finally forms a virtuous circle of "well protected, passed down, and used".

However, technology is not omnipotent, and misunderstandings must be avoided in practical operation. For example, in some places, in order to catch up with the trend of "wisdom", the living scenes in the old courtyard have been completely dismantled and replaced with walls full of electronic

screens, which has actually lost the most precious heritage of fireworks; There are also some places that have built smart participation platforms, but no one maintains them, ultimately becoming "zombie pages". In the future of urban renewal, we must keep the principle of "protection first" in mind, allowing technology to help, while not allowing technology to overshadow culture itself; We still need to broaden the path of public participation, allowing the government to establish a good policy framework, experts to control technology, residents to actively raise demands, and enterprises to find good profit points. Only by working together can cultural heritage truly "live" in the city and become the foundation and driving force for high-quality urban development.

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