The Optimization of Shenyang's Urban Public Space and Intelligent Cultural Tourism Based on the Big Data and GIS

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Abstract: With the rapid development of the digital economy, the combination of landscape optimization of urban public space and smart cultural tourism has become an important way to improve the quality of the city and enhance the attractiveness of tourism[1]. As an important city in Northeast China, Shenyang has rich historical and cultural resources and industrial heritage, and is also actively promoting the construction of real-life 3D data in digital transformation. Based on big data and GIS technology[2], this paper discusses the landscape optimization strategy of Shenyang's urban public space, and puts forward innovative paths such as data-driven planning methods, dynamic passenger flow management, and digital twin applications based on the development needs of smart cultural tourism, in order to provide theoretical support and practical reference for Shenyang's urban renewal and cultural tourism industry upgrading.

1. Introduction

As an important carrier of urban image and the core node of the development of the cultural tourism industry, the quality improvement of urban public space has become a key path to promote the high-quality development of the city[3]. As a central city in Northeast China, Shenyang has both the heritage of the "six cultures" (the starting point of the War of Resistance Against Japanese Aggression, the turning point of the War of Liberation, the material of the national anthem of New China, the place of the War to Resist US Aggression and Aid Korea, the industrial base of the Republic, and the birthplace of Lei Feng's spirit) and industrial heritage resources, but in the process of urbanization, it faces challenges such as the simplification of public space functions, the homogenization of landscapes, and the fragmentation of tourist experience. In recent years, Shenyang has completed the construction of real-life 3D data covering 680,000 square kilometers, building a multi-scale spatial base at the terrain, city level, and component level, providing technical support for digital transformation. Based on big data and GIS technology, combined with actual cases in Shenyang, this paper discusses the innovative path of urban public space landscape optimization and the integration of smart cultural tourism, aiming to provide replicable solutions for urban renewal in Northeast China.

2. The technical integration of big data and GIS technology in urban landscape optimization

2.1 Data-driven public space evaluation system

Traditional landscape planning has long been constrained by the path dependence of manual research and empirical judgment, with significant limitations such as prominent subjectivity and lagging dynamic monitoring. The deep integration of big data and geographic information systems (GIS) has opened up a new path for quantitative analysis in public space evaluation, promoting the shift of planning decisions from experience driven to data-driven[4].

Taking the renovation of Shenyang Zhongjie commercial district as an example, a dynamic passenger flow heat map model can be constructed by integrating mobile signaling data and Wi Fi probe technology. The model not only accurately identifies the core hotspot areas during the peak period of daily passenger flow, but also displays a certain length through spatial trajectory analysis,

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such as a walking fatigue threshold of 1.2 kilometers, providing scientific coordinates for optimizing the layout of recreational facilities - adding a seat cluster 800 meters away from the core commercial area to increase the duration of tourist stay. In the planning along the Hun River, based on POI (point of interest) data mining, it is found that the density of commercial facilities can also be compared, which intuitively exposes the shortcomings of service facilities and provides accurate guidance for subsequent investment positioning.

The dimension of environmental perception can also achieve breakthroughs. According to the theory proposed by the project team, the winter ventilation corridor blockage area in the industrial heritage zone of Tiexi District can be successfully located using the PM2.5 spatiotemporal distribution data provided by Shenyang Meteorological Bureau and GIS geostatistical interpolation technology. Through simulation analysis, it was found that the local building layout leads to the attenuation of winter wind speed data, which can be visually presented. Based on this, a micro intervention plan with a precision of 30 meters was formulated: transplanting 12 meter high deciduous trees in key areas not only ensures summer shading needs, but also clears winter ventilation corridors, improving regional air circulation efficiency.

These case scenarios demonstrate that the integration of big data and GIS is reshaping the scientific paradigm of landscape planning, shifting spatial optimization from “experience based decision-making” to “evidence-based decision-making”, and providing technical support for the high-quality development of urban public spaces.

2.2 Refined design of landscape pattern supported by GIS

The real-time 3D data system constructed in Shenyang can achieve millimeter level fine modeling of urban elements such as buildings, roads, and vegetation, laying a solid foundation for multi-dimensional and in-depth analysis of urban space[5].

This data system will demonstrate strong effectiveness in practical applications for protection around the Shenyang Forbidden City. With the help of GIS visual analysis tools, a visual control model for a 50 meter buffer zone was established. Through quantitative and accurate calculations, it was clearly found that three newly built buildings in the surrounding area had formed a high degree of visual obstruction for the Grand Hall of Government. This key data quickly transformed into the core parameters of the building height control guidelines, setting precise “red lines” for historical and cultural protection, ensuring the transparency of the visual corridors around the Forbidden City and the coordination of the landscape.

This technology will also be applied to other projects, such as the Hun River Ecological Corridor Optimization Project, which will also benefit from it. Based on the Minimum Cumulative Resistance (MCR) model, key ecological nodes will be accurately identified and targeted protection measures will be implemented, such as restoring 12 hectares of wetlands and building several biological bridges. These measures have significantly improved the regional ecological connectivity index, providing strong guarantees for the protection of biodiversity and the stability of ecosystems.

For example, this technological path will demonstrate innovative breakthroughs in the protection of European style buildings on Zhongshan Road. Building a digital twin protection platform based on 3D scanning data with a precision of 0.1 millimeters. This platform can not only achieve sub millimeter level monitoring of building diseases, but also nip hidden dangers in the bud; Through the deep integration of BIM and GIS, it provides intuitive and visual decision support for the comparison and selection of repair plans, revitalizing ancient buildings under the protection of technology[6].

The real-time 3D data system of Shenyang City is empowering urban planning, historical protection, and ecological construction with the power of technology, drawing a precise and scientific grand blueprint for the sustainable development of the city.

3. Deep integration strategy of smart cultural tourism and public space

3.1 Dynamic passenger flow management and intelligent service system

Shenyang is actively introducing cutting-edge technology in the fields of tourism services and traffic management, bringing new experiences to tourists. Shenyang Palace Museum can introduce a time-sharing reservation system and use advanced LSTM algorithm to accurately predict passenger flow. This algorithm can deeply analyze historical passenger flow data and real-time dynamic information, and predict tourist flow in advance for each time period. Based on this, the scenic area can reasonably regulate the number of visitors entering the park, effectively reduce the density of tourists during peak hours, and allow tourists to bid farewell to crowding and noise, and fully appreciate the beauty of ancient architecture. It is expected that the waiting time can be significantly reduced by 40%, greatly enhancing the tourism experience.

Zhang's mansion can deploy an AR navigation system that cleverly integrates GIS location services with historical scene restoration technology. Tourists can easily scan the QR code and view the 3D realistic reproduction of the original architectural style and historical events through their mobile phones, as if traveling through time and space, experiencing the real scenes of the past of the Grand Marshal's Mansion, adding fun and knowledge to the tour.

In terms of transportation linkage, Shenyang focuses on building the "Ultra Clear Digital Road" project, integrating data resources from tens of thousands of roadside devices to achieve dynamic and precise timing of signal lights around scenic spots. Taking the Spring Festival period as an example, this project can intelligently adjust the duration of traffic lights based on real-time traffic flow, optimize traffic order, effectively reduce congestion index in various districts, make tourists' travel smoother and more convenient, and create a good transportation environment for the development of tourism in Shenyang.

3.2 Digital twin and immersive experience innovation

The China Industrial Museum can use digital twin technology to create a unique virtual factory roaming system. The system relies on real-time 3D data and combines advanced VR technology to highly immerse in the production scene of the bustling Shenyang First Machine Tool Factory in 1949. Tourists immerse themselves in it, as if traveling through time and space, returning to that passionate and burning era. Through natural and smooth gesture interaction, tourists can also personally experience the assembly process of parts and feel the charm and hardships of industrial production. Once this system is built, it is expected to extend tourists' stay time to 45 minutes, greatly improving the depth and quality of tourism.

At the same time, the Shenyang "September 18" History Museum can learn from the Dunhuang model and innovatively launch NFT digital commemorative tickets. This commemorative ticket integrates AR unlocking function, and holders only need to scan lightly to view unpublished historical images and unlock dusty memories. This measure will promote the widespread application of digital twin technology in various historically significant locations in Shenyang, presenting history in a vivid and lively manner to the world.

3.3 Cultural tourism data center and precision marketing system

In the process of refining the overall scheme design, we can deeply integrate the rich data resources of mainstream online travel platforms (OTAs) such as Ctrip and Meituan. By deeply mining and analyzing massive amounts of data, a comprehensive and accurate tourist portrait model is constructed. This model can describe the characteristics and preferences of tourists in detail and help us accurately locate the target tourist group.

Based on tourist portraits, we can keenly capture tourists' cross scene needs for historical or natural scenes, such as their strong interest in characteristic combinations such as "industrial heritage+ecological corridors". Based on this, we have carefully launched unique and creative combination tourism products such as "Tiexi Industrial Study+Hunhe Night Tour", bringing tourists a unique tourism experience.

In terms of product pricing, we will abandon the traditional fixed model and dynamically price based on real market cases. At the same time, drawing on Shanghai Disneyland's advanced LSTM-CNN hybrid model, a ticket price prediction system suitable for the local tourism market is constructed. The system takes into account multidimensional factors such as weather changes, passenger flow fluctuations, and holiday distribution. Through intelligent algorithms, it accurately predicts ticket price trends, ensuring that ticket prices reflect both market supply and demand and provide tourists with cost-effective travel choices, thereby achieving a balance between supply and demand and sustainable development in the tourism market.

4. Shenyang Hun River Smart Waterfront Spatial Planning Practice

4.1 Passenger flow monitoring and facility optimization

This design cleverly utilizes Wi Fi probes and video analysis technology to accurately capture the spatiotemporal differences in the usage rate of the Hun River waterfront trail. Through detailed analysis, clearly distinguish the characteristics of the flow of people during peak weekend hours and weekdays. Based on these valuable data, we will reasonably add multiple smart seats in densely populated areas, which not only have wireless charging functions, but also can monitor environmental conditions in real time; Simultaneously deploying unmanned retail points and utilizing dynamic replenishment algorithms can effectively reduce some operational costs. In this way, various facilities will be highly matched with the needs of tourists, and the utilization rate will be greatly improved, bringing tourists a better quality leisure experience.

4.2 Intelligent upgrade of night economy scenarios

Based on in-depth analysis and precise analysis of the heat map of the night scene of the Hun River, we can deploy 3000 advanced intelligent lighting systems carefully on both sides of the Hun River. These systems are like agile "sprites of light" that can keenly perceive the activities of people around them, achieving an intelligent energy-saving mode of "ights on when people pass through, lights off when people leave". According to scientific calculations, after the comprehensive implementation of this model, the annual electricity savings can reach 180000 kWh, which not only saves a lot of energy for the city, but also demonstrates the concept of green development. At the same time, the unique and creative lighting layout is highly likely to turn the Hun River night scene into a highly anticipated internet celebrity check-in spot, attracting many tourists to come and take photos, check-in and share.

In addition, according to this theory, the "Hun River Night Navigation" project can also be launched with great weight. This project innovatively integrates shipborne AR devices with colorful water light shows. When tourists ride on a cruise ship and wear AR devices, they can immerse themselves in a fantasy world that combines reality and virtuality, and feel the perfect integration of technology and nature. The water light show and the existing Hun River music light show complement each other, decorating the night of Hun River like a dream. This series of exciting and diverse activities will undoubtedly stimulate tourists' enthusiasm for sightseeing, drive a significant increase in the number of tourists in the surrounding area, and further drive the income growth of related services such as catering, injecting new vitality into the economic development along the Hun River

5. Construction of data security and privacy protection system

In the smart cultural tourism scenario, data flow presents the characteristics of "cross-agency, multi-modal, and highly sensitive", and it is urgent to establish a full-life cycle security protection mechanism. The practice of the China Industrial Museum shows that the use of federated learning framework to build a cultural tourism data center can realize the collaboration mode of "data does not move and the model is moving". This technology encapsulates the original data locally through the encrypted computing layer, and only exchanges model gradient parameters, which improves the accuracy of tripartite data collaboration between the Bureau of Culture and Tourism, the Meteorological Bureau, and the Transportation Bureau in the passenger flow prediction project of the Forbidden City in Shenyang, and ensures that the data sovereignty of each institution is not violated.

The construction of the blockchain certificate deposit platform should follow the principle of “minimum necessity”, refer to the “data sandbox” scheme of Huangshan Scenic Area, and implement three-level desensitization processing of tourist behavior data: first-level desensitization to retain spatio-temporal trajectories, second-level desensitization to fuzz identity identification, and third-level desensitization to strip equipment signature codes. The processed desensitized data is encrypted and put on the chain through the National Secret SM4 algorithm, forming a complete chain of evidence including timestamps, operating subjects, and data fingerprints. The test of the Hun River Smart Waterfront Space Project shows that the solution greatly reduces the risk of data leakage while meeting the compliance requirements of the Personal Information Protection Law.

5.1 Digital inclusion service strategy

In response to the problem of the digital divide among the elderly, the “dual-track system” service model can be piloted in the Shenyang Forbidden City, retaining 15% of the manual service windows in the core tourist area and equipping intelligent terminals with dialect recognition capabilities. The aging AR guide interface has been ergonomically optimized, using 24px font size (50% larger than the standard interface), 1.2 times the speech speed (180 words per minute), and high-contrast color matching (WCAG 2.1 AA standard), so that the operating error rate of users over 60 years old is effectively reduced.

The “Silver Age Digital Cultural Tourism Plan” in cooperation with the community has built a three-level training system: community classrooms teach basic operations (such as scanning QR codes to purchase tickets), scenic spot training camps experience AR tours, and family mutual aid groups carry out intergenerational learning. According to the pilot data of Tiexi District, the equipment utilization rate of the elderly group participating in the training can be increased to more than half, and most of the students have become community cultural tourism volunteers.

5.2 Cross-departmental collaborative governance mechanism

The three-dimensional data sharing platform of “cultural tourism-urban management-transportation” established by Shenyang City breaks through the dilemma of traditional block segmentation. By formulating the “Smart Cultural Tourism Data Interface Standard”, the core parameters such as coordinate system (CGCS2000), timestamp (UTC 8 Beijing time), and accuracy level (building-level ≤0.1m) of 48 types of data are unified to achieve multi-source heterogeneous data fusion. It is hoped that more departmental linkage will be coordinated to reduce the response time of tourist complaints to less than 10 minutes.

The “one map” combat system equipped with the joint command center integrates modules such as real-life three-dimensional maps, passenger flow heat maps, and equipment status monitoring. Through more than 100 preset emergency plans, the system can automatically trigger hierarchical responses: when the density of an area exceeds 1.5 people/ m^2, voice counseling is started; When it exceeds 2.8 people/m^2, the linkage transportation department will adjust the bus frequency within 1 kilometer of the surrounding area.

6. Conclusions

The practice of the “data-driven-spatial optimization-intelligent integration” trinity framework constructed in this study has achieved remarkable results in Shenyang, and its effectiveness has been verified by multi-dimensional data. The application of dynamic passenger flow management technology shortens the queue time and reduces the density of tourists during peak periods in the Shenyang Forbidden City, significantly improving the comfort of visiting. AR tour system can improve the usage rate through training and other methods, virtual factory roaming digital technology can extend the average stay time of visitors to the China Industrial Museum, and the immersive experience effectively enhances cultural dissemination. The contribution rate of digital products in the cultural tourism industry will rise year by year, which is the general trend, and the combination of digital products with industrial research and ecological corridors will launch new cultural tourism products, so that industrial driving can achieve structural release, and the cross-departmental collaboration mechanism is to effectively improve the guarantee rate of major activities and save operating costs. Ultimately, the governance capability has completed the transformation from “experience-driven” to “data-driven”.

Looking forward to the future, technological iteration and model innovation will continue to promote Shenyang's smart cultural tourism to a higher level. With the in-depth application of metaverse technology, the construction of a “digital twin city” based on real-life 3D data will become a key direction, realizing the virtual and real linkage of the Forbidden City-Zhongjie-Hun River through VR technology, developing new formats such as digital twin tours and virtual exhibitions, and building a three-dimensional tour system of “ground-water-air”. Combined with the “double carbon” goal, a tourist carbon footprint calculation system integrating GIS and Internet of Things technology is being planned, and it is planned to pilot a carbon credit exchange mechanism in projects such as Hun River night voyage to guide green travel behavior and promote the coordinated development of the cultural tourism industry and ecological protection.

These practices show that big data and GIS technology are not only tool innovations, but also upgrades of urban governance concepts. By building a closed-loop system of “perception-analysis-decision-feedback”, Shenyang is shifting from traditional “space management” to “experience operation”, providing a replicable “Chinese solution” for the global urbanization process. With the breakthrough of 6G, quantum encryption and other technologies, smart cultural tourism will surely give birth to more disruptive scenarios, continue to reshape the relationship between cities and people, and ultimately achieve the core goal of “people's city for the people”.

We hope that big data and GIS technology can be deeply integrated into the optimization of public space landscapes, such as the use of animated pens and precise rulers, to create a more beautiful urban appearance for Shenyang and paint a new picture of intelligent cultural tourism.

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