Strategic Research on the Application of Human-Computer Interaction Technology in the Landscape Design of Smart City Parks

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Abstract: In the rapidly evolving era of informatization, the cities upon which people rely for survival are moving towards smart cities. The interactive landscape design of "human + machine + environmental context" plays a crucial role in the smart city park landscape design system, demonstrating characteristics of informatization, gridization, and systematization. This article starts with the current status and development trends of interactive design concepts in smart city park landscape design. It proposes strategies for human-machine interaction technology in smart city park landscape design from three aspects: landscape experience, emotional cultivation, and personalized landscape, with the aim of providing a theoretical basis for the diversified development of smart city park landscape design.

Keywords: Interactive technology; landscape design; experience design; strategic research

1 Introduction

The development of information technology has gradually changed the form and composition of urban landscapes, leading to higher expectations for smart city park landscape design. Interactive landscapes can facilitate the synergistic innovation development of urban intelligent experiences, city services, and landscapes. The application of interactive technology in smart city park landscape design can enhance the diversified connections between people and the city and its environment, bringing people closer to urban landscapes, enriching public experiences, and creating new dynamic ways for people to interact with the urban environment.

The term "human-computer interaction" was first introduced in 1975, and the concept gained popularity with the publication of the book "The Psychology of Human-Computer Interaction" by Card et al. in 1983. The term "Interaction Design" first appeared in 1984, introduced by Bill Moggridge, one of the founders of IDEO[1]. Since then, scholars worldwide have closely followed and researched this field.

The intervention of human-computer interaction technology in smart city park landscape design primarily enhances three aspects: dynamic interaction enhancement in landscape forms, increased public perception of the environment, and the integration of physical and virtual spaces.

Introducing the concept of "interaction design" into landscape design involves utilizing modern science, theory, and materials, integrating new technological approaches and artistic forms to create landscapes that align with the characteristics of the site and meet user needs. It also involves involving people as integral elements in the landscape design process, thereby fostering communication and interaction between people and the landscape[2]. Interactive landscapes not only offer new perspectives for observing cities but also inject fresh vitality into urban environments due to their multifaceted qualities. They provide avenues for communication for urban residents and urban spatial environments. Continuously refining the theory of urban interactive landscapes offers new approaches to address the shortcomings of traditional landscapes and provides a theoretical foundation and reference for the future urban landscape spatial environment.

2 The Current Status and Development Trends of Human-Computer Interaction Technology in Smart City Park Landscape Design

With the rapid development of socio-economic conditions, urban residents have raised higher-level psychological demands for the environments they rely on for survival. The emergence of smart cities is a response to various environmental issues in the process of urbanization. Smart cities meet the development needs of contemporary society, and their operational models facilitate interaction between people and the environment, infusing the landscape with boundless vitality. On the innovative front of smart city landscapes, using technologies like big data, the Internet of Things (IoT), and cloud computing, one can forecast the future directions and trends of urban landscape design. This leads to the rational development of landscapes and the integration of intelligent facilities to meet user needs, thus co-creating ecological, environmentally friendly, green, public-safe, and intelligent new smart city landscape spaces.In China, the application of interactive technology in landscape design has been primarily focused on areas such as website development, interface design, and various fields of research. There have been relatively few theoretical and applied research achievements in interactive landscape design. The current research on interactive technology in smart city park landscape design mainly revolves around theoretical research outcomes, with a focus on the behavioral interaction between the public and environmental spaces. It often overlooks the higher-level need for empathy between the public and environmental spaces. In contrast, foreign countries have been engaged in interactive landscape design practice for a longer time and have a wealth of practical cases, such as Glendale Chess Park in California and Millennium Park in Chicago, Illinois. International practice in interactive landscape design primarily centers around interactive device design, employing high-tech means (AR/VR/visualization technology) for innovative landscape design. The emphasis is on the study of the physical and mental experience of public users. Involving the public in the design process can better enhance the sense of identity and experience of urban residents with regard to spatial environmental landscapes, fostering interaction between the public and urban landscapes, which can provide valuable insights for smart city park landscape design in China. In the context of the global information age, people's lifestyles are rapidly evolving, and influenced by new concepts in smart city park landscape design from abroad, smart city park landscapes must now encompass multiple attributes. Design should go beyond meeting basic functional requirements and include cultural, interactive, recreational, entertainment, and educational elements. The ultimate goal of interaction,

participation, and experience between the public and smart city park landscape design is to transcend the mutual opposition between them and establish a state of mutual dependence. The introduction of an interactive design context transforms smart city park landscape design from a unidirectional "lecture-style" output to a "dialogue-style" two-way exchange. Only through integration can true interaction between the landscape and the public be achieved, becoming an effective means to showcase the substantive development of smart city park landscape design.

With the rapid advancement of information technology, the future development of landscape design systems will be a fundamental consideration for future designers. Compared to traditional smart city park landscape design systems, new forms of interactive landscapes, such as perceptual and psychologically projected types, offer more diversified ways of interaction. In the future, the ability of designers to perceive diversity can be effectively combined with tangible material space and AI virtual analysis tools. This combination, through a control-coupling mechanism between tangible material space and intangible image grids, expands people's perception capabilities of landscape systems, enabling designers to provide better design feedback. The physical elements of urban landscape systems themselves possess dynamics, while non-material elements do not inherently have dynamic expressions. Future urban landscape systems will need to incorporate devices to transform invisible data into tangible, visible representations to achieve interaction spaces for people's interactions in terms of time, scale, and physical space. Nevertheless, the future of urban landscape systems should still prioritize improving the ecological environment, enriching landscape diversity, and satisfying people's demands. It should aim for interconnectivity in landscape sightlines, spatial continuity, and cultural continuity, among other aspects.

3 Interactive Landscape Design Strategies in the Construction of Smart Cities

In the construction of smart cities, various industries and subsystems within the urban landscape are interconnected and collaborate through the smart city social system. People have diverse access to information, and their needs manifest in various ways. Traditional landscape designs, due to their neglect of the interaction between people and the environment, no longer meet the current demands, highlighting a mismatch with the current smart city development. Through human-computer interaction as a crucial link, it is possible to enhance the relationship between urban landscapes and the public, integrating smart elements into all aspects of the city.

3.1 Enhancing Perceptual Interactive Landscape Experience Design Strategies

In 1976, the International Geographical Union introduced the theory of environmental perception (Perception of Environment), which aimed to enhance the understanding and evaluation of the 'human-environment relationship' by studying human environmental perception and spatial behavior. Geographer R.J. Johnston outlined the components of human environmental perception as experience, cognition, and sensation, providing an intuitive understanding of the inherent attributes of environmental perception. Environmental perception refers to the psychological responses made based on the information obtained through the senses. These responses represent an individual's subjective interpretation of environmental elements based on their existing experiences, which is why perception is often referred to as

perceptual experience[3].

Humans are the actors in the landscape spatial environment, and one prevalent research area in interactive landscapes is how to interact with human behavior. People use their senses to gather various information from the external environment, such as through the five senses: vision, hearing, smell, taste, and touch. Corresponding to these senses are the media that directly stimulate human perception (Perception Medium). In interactive landscape design, by stimulating one of these senses, other sensory systems can be triggered, creating a synesthetic response that allows the public to experience a comprehensive sensory and emotional immersion. Interactive sensory systems are an integrated entity that interacts and influences each other, with sensory information being a process of mutual influence and permeation.

In interactive landscape design, visual sensory experiences mainly fall into three categories: spatial environmental visual stimuli, light and shadow variation stimuli, and comprehensive stimuli. Spatial environmental visual stimuli primarily involve the interplay of points, lines, and surfaces in spatial forms, providing a visual sensory experience to the public. Light and shadow variation stimuli use natural environmental light or artificial landscape lighting to create a myriad of light and shadow effects that guide participants to feel the landscape, enhance interaction between people and the landscape, and achieve a true interactive experiential blend of emotions within the scene. Comprehensive stimuli primarily involve using various design techniques such as different materials, light and shadow variations, and spatial environments to transform static landscapes into dynamic forms, creating interactive landscapes that engage multiple senses, fostering rich landscape experiences, and promoting a shift from passive appreciation to active participation, achieving genuine landscape interaction effects.

Once people have satisfied their basic needs for use and observation, they seek higher-level psychological needs. Therefore, the landscape design of urban public spaces is transitioning from traditional implicit viewing modes to explicit participation modes[3]. The application of interactive concepts in smart city park landscape design uses information technology to facilitate a dialogue between people and landscapes, creating diverse and distinctive landscape environments, and achieving intelligent services.

3.2 Enhancing Perceptual Interactive Landscape Experience Design Strategies

Environmental behavior studies suggest that in landscape spaces, human behavior patterns can be broadly categorized into two main types: the 'needs' pattern and the 'field force' pattern[4]. The 'needs' pattern is based on the inherent cognitive level of the public regarding the spatial environment, while the 'field force' pattern is based on the behavior resulting from external information influencing the public. Behavioral interactive experiences in smart city park landscape design can be divided into three categories: habitual behavior interaction, situational behavior interaction, and guided behavior interaction. Habitual behavior interaction refers to specific behavior patterns and is typically unconscious. Different behavioral habits lead to different landscape experiential perceptions[5]. For example, individuals walking in urban landscape green spaces instinctively seek visual focal points, resulting in different experiential levels depending on their line of sight. Situational behavior interaction inherently has spatial limitations, as people have different sensations in specific scenes and contexts. For instance, different functional zones in urban park landscape design are designed to evoke different emotional experiences. Guided behavior interaction involves designing behavior based on the

needs of individuals. In smart city park landscape design, designers guide people's movement trajectories in the spatial landscape environment scientifically and sensibly, starting from people's physiological and psychological needs, thereby enhancing people's experiential richness within the spatial environment.

Interactive landscapes involve a form of behavior that occurs between the public and the landscape spatial environment, providing users with a quantitative sense of satisfaction and pleasure. Behavioral interactive design involves configuring interactions between people and the landscape based on the layout of the spatial environment, various interactive installations, spatial structural forms, user groups, interactive modes, and user feedback to achieve interaction between people and the landscape. Behavioral interactive landscapes serve as a medium for conveying public behavior, triggering interactive behavior and creating emotional and psychological interactions. Firstly, at the level of behavioral interaction, attention needs to be given to the degree of public participation in the landscape environment, the medium through which behavior occurs, and the connections between various functions to enhance the pleasure and satisfaction that behavioral interaction brings to users. Secondly, users from different cultural backgrounds and age groups have different emotional demands. By identifying user types and considering their habits and requirements, designers can create a comfortable, humanized smart city park landscape design, making the design more rational. Finally, by analyzing user behavioral interaction patterns and utilizing diverse spatial combinations along with other technological installations, designers can promote the occurrence of interactive behavior. With behavior driving the application of technological means in landscape effects, the design becomes multi-layered, interesting, and satisfying users' desire for interaction and emotional fulfillment with the landscape.

3.3 Enhancing Emotional Interaction in Landscape Experience Design Strategies

A great landscape design work should not only meet the functional needs of its users but also establish an emotional connection between the landscape and people. It's about experiencing it with both the body and the heart, a process of association and experience between humans and the natural landscape environment, resulting in emotions generated by the subject's physical activities and emotional sublimation through interaction with the object.

Emotional interaction represents a higher-level psychological experience, where "emotion" primarily resides in the feelings of individuals. This emotionalized experience serves as the guiding principle for design. It resonates with the audience by infusing emotions into the landscape, creating a blending of emotions within the scene. As people's needs for use and observation are satisfied, there is a gradual shift towards experiential and higher-quality services. Therefore, landscape design in urban public spaces is transitioning from traditional implicit viewing modes to explicit participation modes[3]. Based on temporal and spatial characteristics, emotional interaction can be categorized into three types: anticipatory emotional interaction, immediate emotional interaction, and reflective emotional interaction. In anticipatory emotional interaction design, the design theme takes center stage. Anticipatory emotions refer to the expectations individuals have about the upcoming landscape space environment. Through metaphorical design approaches (symbols, colors, time and space), creating the right atmosphere, and scenario enactment, participants gain initial awareness of the spatial environment and experience resonant interactions. Notably, creating a thematic atmosphere places a specific theme in a particular location, allowing participants to understand

the landscape theme through certain technical means, ultimately leading to a fusion of human and landscape. Immediate emotional interaction design involves the interaction of subjects and objects in a specific spatial environment and exhibits strong transient characteristics. It primarily relies on participants to create a specific environmental setting and the appropriate atmosphere, serving as a process of intertwining landscape narrative ideas with emotional resonance. In smart city park landscape design, designers should delve into studying what kind of landscape model to create and what atmosphere to cultivate. The specific design strategy here is "scene enactment," which can also be understood as "storytelling." Consideration should also be given to the spiritual aspects brought about by individual differences. Reflective emotional interaction occurs after a period of time and experience in the interaction between subjects and objects[6]. "Reflection" is a fusion of rationality and emotion that takes place at the conscious and cognitive levels. Reflective emotional interaction captures the meaning of the landscape, the influence of thoughts, the ability to share experiences, and cultural impact. Unlike the other two levels, it is deep and gradual. Its ultimate goal is to achieve a sustainable fusion between the landscape environment and users, with the aim of achieving a value upgrade for the individual.

Interactive landscapes follow a closed-loop design process with a lifecycle. The three levels of interactive landscapes are interconnected and progressive, with interactions and influences between them. They collectively form the core subject of interactive landscapes. Designers should focus not only on the functional aspects of the design but also on the emotional resonance between users and elements such as the spatial environment and the landscape. Only through this can the vitality of urban landscapes be extended to meet the diverse needs of the current audience.

4 Design and practice of the intelligent sports park in Wuming Mountain, Yuncheng

The Wuming Mountain Park is located in Yuncheng County, Shandong Province, and belongs to the warm temperate semi-humid East Asian monsoon continental climate. The four seasons are distinct, with dry and windy springs, hot and rainy summers, mild and cool autumns, and dry and cold winters with little rain or snow. The average annual precipitation is 694.7 millimeters, and the average number of precipitation days per year is 71.4 days, with the most rainfall occurring in July and the least in January. The design section of Wuming Mountain is located at the intersection of Qingze Road and S242 Provincial Highway, covering an area of approximately 23.6 hectares. The design of the intelligent sports park mainly includes conventional intelligent systems (intelligent video surveillance, intelligent broadcasting, intelligent street lights, smart parking lots), a national fitness intelligent audio software system (pushing music rhythms suitable for different groups based on their exercise preferences and characteristics), fitness equipment cloud management system (managing all fitness equipment in the area), intelligent monitoring system, smart maintenance management, intelligent environmental monitoring (real-time monitoring of temperature, humidity, PM2.5, noise, light intensity, etc. in the park. Uploading space environmental data directly to the cloud and displaying it on a big screen in real-time), intelligent irrigation, intelligent interaction (artificial intelligence running track, AR interaction), intelligent venue management system, intelligent tour guide system, park HSE management, abnormal alarms, one-button alarms, AI passenger flow visualization analysis system, etc.

4.1 Intelligent Running Track - Non-wearable AI Sports Monitoring

In the park facilities survey, it was shown that visitors have the strongest demand for intelligent running systems. The smart running track in the park combines fitness activities with intelligent facilities through technological means, providing a non-wearable AI sports monitoring system to meet the fitness needs of visitors and improve their enthusiasm for exercise. Its main features include: (1) After registering on the sports system, runners can run on the intelligent running track. The motion detection camera can recognize and track the runner's personal information data, count running time, distance, segment pace, provide physical data, and calculate energy consumption and other motion data. (2) Runners' motion data can be viewed in real-time on offline terminal devices, as well as in the small program's personal center, where they can view their own running rankings, average pace, maximum speed, accumulated running mileage, and other motion data within the park. (3)The motion detection system also has an alarm function for situations such as runners collapsing due to fatigue or suffering injuries from accidents or attacks, which is linked to the park's monitoring center to customize rescue plans for visitors and ensure their safety. (4) In some scenes of the smart park, the motion detection system can be used to check whether the runner's running posture is standard and reasonable in real-time, push relevant information and give some guiding suggestions to the runner. (5)With the help of AI voice recognition technology, after the system analyzes the runner's exercise history, it can broadcast the motion data and remind them to rest while providing detailed information on surrounding landscape trees, light music, and other types of leisure services, allowing for interaction and communication between the runner and the environment at a psychological level.

In areas where park conditions allow, non-contact and non-invasive measurements of the runner's heart rate and respiratory data can also be taken. The system also includes intelligent interactive projects such as time and space travel, walking with you, running for more happiness, and staying young through exercise, to increase visitors' participation and interest in fitness activities within the park.

4.2 Intelligent Interactive Facilities - Smart Exercise Equipment

Smart exercise equipment can record the frequency of equipment exercises and display the exerciser's energy consumption through the health algorithm built into the intelligent fitness platform. Its main features include: (1) With facial recognition technology, the exerciser's basic personal information can be accurately detected within the overall control system and transmitted to the corresponding connection established by the intelligent system for timely transmission of exercise data. (2) First-time users of smart exercise equipment do not need to register; they can directly enjoy borrowing and returning services through the mobile app, log in to their personal account on the intelligent exercise page, and link to the corresponding smart exercise equipment. (3) In the intelligent data cloud system, by using the mobile scan function, exercisers can not only view instructional exercise videos but also access their own exercise data. They can convert the energy from their exercise data into corresponding points and add it to their individual intelligent exercise account system. (4) By incorporating competitive and entertaining elements into the smart exercise equipment, the fun and participation of visitors in the park can be enhanced effectively based on various factors such as different exercise projects, age groups, exercise intensity, and frequency. It also increases interaction between users. (5) Users can integrate their personal exercise data on the smart trail big screen via the mobile app,

timely and accurately check their rankings, maximum pace, speed, accumulated mileage, and energy consumption values in the intelligent exercise park.

4.3 Intelligent Facilities - Smart Seating

In addition to meeting basic rest functions, the design of smart seating includes expandable features such as lighting, Wi-Fi base stations, USB charging, and Bluetooth speakers, which greatly increase the usage rate of health trails, rest areas, and fitness areas. At the same time, smart seating can also use solar energy for power supply. The USB fast charging port can provide power to mobile phones, tablets, and other electronic devices throughout the day. When the lighting conditions are insufficient at night, the LED lights will be automatically turned on for illumination. Compared with traditional power supply methods, the smart power supply system of the intelligent seating realizes the supply of clean energy while reducing electricity consumption and saving labor costs. The smart seating is also equipped with an AI intelligent Bluetooth speaker device that can connect to the user's smart device. While users are resting, they can enjoy music services played by the smart seating. In the cold winter weather, it also has a heating function. The use of this smart seating device can result in long wait times in fixed locations, so a smart charging treasure borrowing service is set up to compensate for the inability to carry the smart seating charging facilities.

4.4 Intelligent Facilities - Smart Sports Equipment Rental

Smart sports equipment rental cabinets are an important part of the National Fitness Smart Park and the core technology component of the intelligent trail. They integrate IoT, cloud computing, artificial intelligence, and big data to create a shared fitness solution for small equipment based on the smart sports ecology. The rental cabinets are placed at various points in the park and offer a variety of small fitness devices. During their leisure time after exercise, as long as they scan the QR code with their mobile phone, exercisers can get the exercise equipment they need.

4.5 Intelligent Facilities - National Running Fitness Convenience Store

The national running fitness convenience store under the internet environment is a new form of fitness that mainly integrates AI artificial intelligence technology, IoT technology, and big data technology to create a new concept of fitness convenience stores, breaking down many barriers of traditional gyms, and promoting national fitness with extreme cost-effectiveness. Its main features include: (1) One-click self-service fitness: Scan the QR code on the machine body to start a convenient fitness experience, greatly reducing the time cost of fitness. (2) Business-level customized equipment: Designed specifically for the community fitness group, it is durable and reliable with the self-developed motion control system. (3) Spliced cabin design: It can form combinations of different functions and sizes according to site conditions, environment, and modeling requirements, meeting different fitness experience requirements. (4) Intelligent voice butler: Voice prompts users with personal exercise data, equipment operation guidance, reminders, safety tips, and warnings not to be used or played by children. Entering the app or mini-program voice reminds users of their fitness plan progress, assisting in developing a correct exercise plan. The intelligent big screen can update the real-time movement rankings or other customized content.

5 Conclusion

In today's rapid digitalization era, digital technology and mindset have been driving the development of smart city park landscape design. With the integration of interactive technology into smart city park landscape design, modern smart city park landscape design has transcended the boundaries of traditional landscape design. It requires the infusion of new technological means, new conceptual approaches, and innovative ideas. By utilizing relevant theories and design methods of interactive design, it can achieve a higher level of depth in the relationship between people and the environment. Interactive landscape design is a new type of landscape that adapts to the development requirements of the current information age and the needs of users. Harvard University's Kappel and Hozman predict a paradigm shift, where intelligent machines and landscape systems will coexist and develop efficiently within the landscape environment. Interactive landscape design uses the landscape as a medium and intervenes in the practice of smart city park landscape design with scientifically sound design concepts and methods. It combines various technological means for digital quantification and analysis, integrates elements such as regional culture, human geography, historical context, and customs, and truly realizes the interactive experiential design of modern smart city park landscape design. In practice, it creates interactive landscape environments that communicate and interact with people, allowing smart city park landscape design to truly return to a human-centered approach and build a new-generation smart city park landscape design system for the new era.

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