Application of IoT Monitoring and Maintenance Management Systems in Urban Parks under the Background of Smart Landscaping

Fen Ye

Heifei Runkai Real Estate Development Co., Ltd., Hefei, Anhui, 230000, China

Keywords: Smart landscaping; Urban parks; IoT monitoring; Maintenance management system

Abstract: With the new stage of China's urbanization entering high quality, Urban parks are core spaces in the pursuit of urban ecological balance and meeting residents' leisure needs, so innovative model management among them has become one of important parts of smart city construction. At present, there have been some national-level policies guiding the digital transformation of green spaces which clearly define technological empowerment as a main track for improving landscaping management efficiency and provide directions for urban parks to break through the bottleneck of traditional management. This article on smart landscaping work explains the use of IoT monitoring and maintenance management system for urban parks. This not only addresses the need to improve the utilization efficiency of park resources, but also effectively reduces management costs, improves park ecological quality and visitor recreation experience, and provides a scientific path for the intelligent development of urban parks.

1. Introduction

As China's urbanization process continues to impact rapid, urban parks an important component of the urban ecosystem and public service system also increasingly prominent green space ecological regulation functions leisure recreation Cultural display. Traditional urban park management models are dependent on manual styles and empirical decision making, which has shown many shortcomings in dealing with large-scale park greenspaces. At the same time, national policies like the "14th Five-Year Plan for Promoting Agricultural and Rural Modernization" and the "Smart Landscaping Construction Guide" have been released one after another, clearly putting forward requirements for promoting digital and intelligent management of green spaces, providing policy support for the smart transformation of urban parks. To this end, building a park monitoring and maintenance management system IOT is one of the main directions for intelligent park construction, it is also significant for optimizing urban ecological environment standard and living residents life better quality demand.

2. The Core Connotation and Development Trends of Smart Landscaping

Through digital and intelligent means, smart landscaping is not the simple overlay of technology but a new development model that highlights the ecological functions and public service value of landscaping, optimizes the real-time operation and maintenance management process throughout [1]. Its core connotation is reflected in three dimensions: first, the omnipresence of perception, breaking through traditional manual monitoring capabilities to realize real-time capture of multi-dimensional information such as ecology, facilities and services within the landscape; second, scientific decision-making rather than empirical judgment based on data analysis, so that maintenance management and service optimization measures are more closely aligned with the practical needs of the landscape; third, synergy of operations to promote linkage between landscape management and urban ecological governance and public services, forming a positive interaction between "landscape–city–residents."

From the perspective of development trends, smart horticulture is gradually deepening to "system collaboration" rather than completely liberating the original "single-function intelligence." Early smart landscaping now mainly focuses on the application of technology in a single link, such

  DOI: 10.25236/icacel.2025.177

as automatic irrigation or smart lighting, while nowadays more attention is paid to building a complete smart management system. Under the background that the construction of ecological civilization deepens, the use of smart landscaping is more and more not only to pursue efficiency improvement but also rooted in ecology, which will become an important orientation for smart landscaping development (from artificial landscapes to ecological carriers; rich ecological functions) spirit; provide strong support for urban sustainable development.

3. Design Principles for Urban Park IoT Monitoring and Maintenance Management Systems

The design of an urban park IoT monitoring and maintenance management system should serve the practical needs of park management, laying a foundation for the long-term stable operation of the system, needs to adhere, in particularly, to these four fundamental principles.

3.1 Practicality Principle

System function design should closely revolve around the core needs of park monitoring and maintenance, resolutely avoiding the tendency to pursue technical complexity at the expense of practical application scenarios. When developing the function, fully consider the actual operation habits and profession knowledge background of management personnel in daily work, reduce redundant operation links (such as reducing unnecessary hierarchical transition, reasonable entry position of functional areas), make sure that management personnel can master the system operation method within a short time through relatively simple steps to achieve rapid transformation from technical advantages of the system into practical results on improving management efficiency and quality.

3.2 Compatibility Principle

Design must take account of the access requirements of existing park management equipment and recognise future technology upgrade and expansion potential. Reserved adaptation space when determining other key technical parameters such as hardware interface standards (protocol standards, simulation interfaces, etc.) and data transmission formats in order to ensure smooth evolution. Such as: Use universal interface types, such as RS485 and Ethernet; Support mainstream data formats, such as JSON and XML; Prevent the closed system architecture from bringing compatibility problems in future equipment upgrades or functional expansion; Finally realize the seamless connection with monitoring equipment and management platforms of different brands and models, achieve efficient mutual transmission between multiple systems smooth data.

3.3 Real-time Principle

For some applications that require immediate response, such as rapid changes in park ecological environment parameters and real-time fluctuations in the facility equipment operating status, the system should establish an efficient data processing pipeline. With highly efficient data transfer protocols and analysis algorithms, ensure that the transmission of data from collection terminals to analysis modules is highly timely, allowing management decisions to accurately follow onsite dynamic changes. This avoids such problems as expedition of maintenance and the deterioration in quality of service for visitors during transmission beats.

4. Practical Application Scenarios of the IoT Monitoring and Maintenance Management System

4.1 Ecological Environment Monitoring and Dynamic Regulation

Through continuous monitoring of the main ecological indicators of the park as the core, relying on a regional wide ecological environment perception network becomes an important method for urban park community ecological management in practice. Unlike a simple aggregation of devices, this network provides accurate coverage within the monitoring scope through the zoning of natural parks according to topographic features and ecological sensitive points. The system functions in this

application scenario emphasize the dynamic change process of the park's micro-environment. In particular, it is able to utilize multi-dimensional sensing devices for real-time monitoring of core factors that impact ecological balance, therefore providing comprehensive and accurate references for managers to know current environmental status without having to wait for complex data interpretation.

4.2 Precision Plant Maintenance Management

Core to the precision plant maintenance management scenario is the principle of "adapting it to all stages of the growth cycle of a plant. It uses the basic form of the IoT`s system to form an IMAE ("monitoring-analysis-decision-execution") closed-loop management system that realizes dynamic tracking of growth status and scientific optimization of maintenance measures [2]. This is far from the "unified management" that was mainly for traditional maintenance, but instead starts from the differentiated requirements of each single plant and community to enable more personalized technology-based support for monitoring. In particular, the ability of integrating this system can overcome traditional maintenance models which rely on experience judgement. Data drive replacement maintenance, would rather than using "fixed-cycle fertilization and unified time irrigation" to carry out maintenance, develop personalized maintenance plans according to different plant species or growth stages. So that maintenance measures can match the actual needs of plants closely, avoiding over-maintenance or under-maintenance problems and improving the accuracy and effectiveness of plant maintenance.

4.3 Intelligent Operation and Maintenance Management of Facilities and Equipment

In the scenario of park facility and equipment management, the it will be in IoT system to realise the tracking of the facility operating status integrated with big data decision algorithm for improving operational efficiency, constructing a life cycle comprehensive coverage of facilities management system covering: "procurement-installation-operation-maintenance-disposal". The system collects key data in real time during the facility operation with the deployment of specialized sensing modules on landscape facilities, to dynamically grasp the operating status of facilities and timely identify abnormal conditions in facility operation. After the system detects a facility fault or potential failure risk, it issues early warning to alert through platform alerts, SMS notifications that instant synchronizing information such as fault location, type and impact scope to management personnel. This enables rapid identification of the location of a problem, and then for scheduling maintenance staff to address it in a timely manner so as to reduce risks caused by prolonged operation of faulty facilities.

5. Application Strategies for IoT Monitoring and Maintenance Management Systems in Urban Parks under the Smart Landscaping Background

5.1 Building a Technology Adaptation System Tailored to Park Scenarios

In the construction practice of urban park IoT system, technology adaptation must start from the specific characteristics of park scenario as its core starting point, resolutely avoiding the "homogenization" problem of technical solutions that can not adapt to scenarios.

In the first planning phase, systematical research on relative park scenario characteristics should be performed prior to investigating technology potential and non-park development in order to define better spatial attributes, ecological composition and management goods. This means that the monitoring priorities and maintenance differences of the different functional areas will be defined. E.g., ecological conservation areas should strengthen monitoring of indicators such as soil moisture and vegetation growth status; leisure activity areas need to pay more attention to real-time tracking of facility operating status and visitor flow.

At the software level, all the operational needs of management personnel shall be taken into consideration. The threshold for using system functions should be lowered through the optimization of function modules and simplification of operational processes, giving priority to avoiding

problems that lead to low management efficiency as a result of excessive technical complexity. Graphic display：In the link of data presentation, through visual interactive interface design, turn multi-dimensional monitoring data into intuitive line charts/bar charts/heat maps, or use "normal/ abnormal" status indicators and warning pop-up reminders to quickly grasp key information in the process of management, so as to reduce the time cost of interpretation. In the function design link: Based on the actual demand of park management, combine with the importance of ecological monitoring data query module, intelligent maintenance task reminder module and automatic facility fault alarm as high-frequency capability development core modules. Remove superfluous low relevance functions to daily management to prevent the dispersion of managers´ operational attention. Keep system iteration of function and performance updates in sync with the development of smart landscape works, adaptive adjustments to the dynamic changes in park management needs for a longer time period [3].

5.2 Promoting Deep Integration of Management Processes and System Functions

The essence of its application to the system is to organically and naturally rely on the existing park management system rather than having a state of "technology + management parallel operation".

In first it is needed to associate the regular park management processes in a methodical way and re settle before modernizing. By the means of process decomposition, it can help to identify inefficiency links and information breakpoints, so as to clarify which nodes need intervention and what are the functional boundary points of IoT system in the whole management chain of "data collection-analysis decision-execution feedback". Taking the maintenance management process as an example, the system deployment can replace the fixed-time fixed-point recording mode of traditional manual inspections. To solve the lag/errror problems of manual records, when using sensing devices it achieves real-time dictiation of plant growth status and soil environment. Use the built-in system data analysis model to utilize monitoring data based on actual plant growth laws, and replace the decision-making method relying on managerial experience with scientific maintenance suggestions. At the same time, use the feedback module of the system to monitor in real-time the execution progress and effect of maintenance measures on site, thus forming a closed-loop management mechanism of "monitoring-decision-execution-evaluation", which promotes and guides park maintenance management processes from traditional "experience-driven" to accurate "data-driven" [4].

Secondly, in order to deal with the management barriers between internal park departments, a data collaboration mechanism should be established based on IoT system. Under the common park management model, ecological watching, plant care, facility control and visitor services frequently work in a each doing well style. Each department maintains its own ledger or system, making data sharing difficult and therefore leading to a low efficiency of management synergy. The IoT system is establishing a new type of unified data sharing platform to help various departments break their information silos and achieve real-time coordination and efficient data flow across different management links: Facility Management Department can use the platform to get dynamic visitor flow data, optimizing inspection frequency and maintenance priorities for facilities like fitness equipment and lighting equipment at peak hours; The Ecological Monitoring Department can share environmental data (such as air temperature, humidity, soil nutrients) with plant maintenance department in real time as quantitative basis for making irrigation and fertilizer plans for different vegetation; The Visitor Service Department can optimize service resource allocation strategies based on facility operating status data so as to greatly improve overall synergy level and decision-making accuracy of park management.

5.3 Establishing Long-term System Operation and Risk Prevention Mechanisms

The effective long-term benefit of the system is mainly based on a reasonable operational guarantee and risk prevention system, which requires construction from multiple dimensions. Daily operation and maintenance: A unified operation and maintenance management system needs to be

built, working process, loops of systems always keep the systems running smoothly stably. First, should form a regulation on operation and maintenance of all elements including equipment, data, and network element, that is the specific cycles of perception device inspection operation and maintenance specification along with corresponding operations for system data maintainabilityas well as transmission network debugging.

By dimension of cost control, a full-cycle cost balance mechanism for "construction-operation" should be established to avoid unsustainable system operation with excessive investment. In the equipment selection stage, we will establish a "performance-cost" evaluation model focused on competitive products where cost distribution is easy to attend and compute production later. Example: Use ultra-low-power self-sufficient solar powered equipment to minimize the laying cable and electricity consumption in non-mission critical monitoring hotspots. In the technological upgrading link, it is necessary to establish an upgrade priority based on the actual needs of park management instead of blindly following new technologies, so as to avoid waste of cost. As an example, when the basic decision making needs are satisfied with existing data analysis functions, there is no incentive to enforce AI technologies of complex modeling. Based on managing operation and maintenance labor cost, to promote individual operational effectiveness by optimizing operational processes and conducting skill training for management personnel, through reduce labor input.

6. Conclusion

To conclude, the integrated IoT Monitoring Maintenance Management system of urban parks is not only a new technology used in smart landscaping but also one that reflects a systematic re-engineering management model. The three solutions proposed in this paper—technology adaptation, management integration and long-term operation—provide the systemic implementation pathways from different dimensions. They are inter-related and complementary, driving the system to evolve from a process of functional building to value realization [5]. Due to the further integration of IoT with big data, artificial intelligence and other technologies in industrial production and life, it is expected that the urban park IOT monitoring and maintenance management system will be able to move toward more intelligent, deeper development in the future. Performing intelligence to contribute to the sustainable development of parks shall go a long way in supporting the creation of an ecological and livable urban space.

References

[1] Yang Maoxue. Park Landscaping and Maintenance Management Measures under the Background of Smart Landscaping [J]. Smart China, 2025(7): 94-95.

[2] Li Jifen, Chen Yuntao. Plant Protection Strategies and Technological Innovation under the Background of Smart Landscaping [J]. Modern Gardening, 2025, 48(12): 161-162, 165.

[3] Zhang Chaorong. Park Landscaping and Maintenance Management based on the Background of Smart Landscaping [J]. Low Carbon World, 2022, 12(7): 184-186.

[4] Zhang Panpan. Analysis of Park Landscaping and Maintenance Management under the Background of Smart Landscaping [J]. Journal of Smart Agriculture, 2022, 2(6): 4-6.

[5] Qin Xuan. The Value of Landscape Big Data Development under the Background of Smart Landscaping Planning and Construction [J]. Southern Agriculture, 2021, 15(21): 53-54.