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RESEARCH ON THE APPLICATION OF INTELLIGENT CONTROL SYSTEM IN URBAN LANDSCAPE LIGHTING

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Abstract: This article studies the application of intelligent control systems in urban landscape lighting. With the further integration of Internet technology and LED chip technology, urban landscape lighting has entered the era of intelligence. Traditional switching control methods can no longer meet the needs of modern urban landscape lighting, and the development of intelligent control systems provides a new solution for urban landscape lighting. This article analyzes the advantages and application cases of intelligent control systems in urban landscape lighting, and explores the future development trends of intelligent control systems. Intelligent control systems can achieve remote control, real-time monitoring, and data analysis and other functions, providing more refined management methods for urban management departments. In the future, with the continuous advancement of technology and the continuous expansion of application scenarios, intelligent control systems will play a more important role in urban landscape lighting.
Keywords: Intelligent control system; Landscape lighting; Urban space

1 INTRODUCTION

With the development of The Times, the Internet technology and LED chip technology are further integrated. With the combination of Internet technology and LED chip technology, the 2013 Nanchang Ganjiang River Light Exhibition in Taiwan region took the lead in setting the national trend and became the driving force of the growth of urban night view economy. Various places have followed suit, such as the Hangzhou G20, Qingdao Shanghai Cooperation Summit and other projects, beautify the city night scene, but also drive the development of related industries. These projects not only demonstrate the combination of technology and art, but also become a new driving force for urban economic development.

In the early stage, the landscape lighting in many cities adopts the traditional clock-controlled switch mode. In this way, the switch time is already set during the project acceptance or handover. If it needs to be adjusted, a lot of manual operation is required, which is both time-consuming and laborious. Moreover, the adjustment of the real time cannot be synchronized with the cycle change, it cannot be flexibly and quickly adjusted and controlled during holidays or major activities, and it is more difficult to achieve remote control and fault detection, resulting in landscape lighting management difficulties.

After nearly 20 years of development, the urban landscape intelligent control system has experienced the evolution from the traditional clock control to the "three remote" and "five remote" control mode, and then to the intelligent remote table reading and real-time data upload function. In recent years, the system is moving towards the direction of intelligence, and significant progress is being made in remote control, optical remote control, portable operation, multi-screen collaboration, video surveillance and security protection interconnection mode. However, due to historical, technical and economic reasons, there is a large gap in the construction schedule of the urban landscape lighting control system, with some common problems. From all the studies above, the conclusion of construction problems of urban landscape lighting control system can be listed as Table 1.

Table 1 Table of the construction problems of urban landscape lighting control system

Rank	The sorting table of the construction of urban landscape lighting control system
1	Lack of overall planning, disorderly construction time, and independent regional governance, resulting in decentralized management, delayed response, and difficult coordination between departments
2	Simple functions, traditional scenes, lack of fine management, failed to make full use of the new technology to update.
3	Not effectively connected with the smart city big data platform, and the phenomenon of information island is serious.
4	Network and security system operation and maintenance management standards are not unified, which increases the difficulty of management.

2 CURRENT STATUS OF DOMESTIC AND INTERNATIONAL RESEARCH

2.1 Domestic Research Status

2.1.1 2016 "G20 Summit" hangzhou landscape lighting performance project

In order to welcome the "G20 Summit" in Hangzhou, in 2016, the highlight of the new round of Hangzhou landscape lighting improvement project lies in the control system integration and centralized management platform "single knife switch control system". In the same year, the world-famous Hangzhou G20 Summit " was successfully held, and the Qianjiang New City Media Facade Lighting Performance Project also achieved great success, which was highly praised by the leaders and the masses. The project shows the beautiful scenery of the Qianjiang New City business district, making it a new cultural name card of Chinese culture. The project installed 700,000 LED point light sources on the facades of 38 high-rise buildings more than 100 meters high, showing superscale images 2 km long and 100 meters high. The main visual observation points are the city balcony and the Olympic Stadium. At the same time, nearly 200 buildings along the Qiantang River have also lit up the atmosphere circle.

"Impression West Lake G20 version" is a large-scale waterscape performance symphony concert directed by Zhang Yimou. The centralized control system platform of the project is very advanced, including the main core control system, 8 sub-regional control centers, 7 sub-electronic touch points, etc. In addition, there are 15,000 sets of LED light source lights, with a color temperature tone, dual control system and other integrated functions. The equipment adopts special optical fiber and cable as the main optical cable signal transmission mode, and the wireless signal transmission serves as the auxiliary, which improves the signal smoothness, technical reliability and timeliness of activity. The system also combines "unified control" and "independent subsystem control", and adopts RDM system and GIS system, with the function of online state monitoring, data feedback and abnormal data alarm, and can quickly locate the data address. This system has become a complete, ecological, two-way feedback intelligent system, providing strong technical support for the activities [1].

2.1.2 Light show case of the 40th anniversary of reform and opening up

The light show project of Futian Civic Center for the 40th anniversary of Shenzhen's reform and opening up takes the civic Square and 43 surrounding buildings and green belts on both sides as the carrier, and adopts centralized intelligent control to form the media facade linkage. Different from the night views of the G20 Summit in Hangzhou, Xiamen Wuyuan Bay and Qingdao Fushan Bay, the space is arranged in a "U" shape, most of which are super high-rise buildings, including one building of 600 meters and 6 buildings over 280 meters, which brings challenges to the distribution of point light sources of media facades. To this end, the combination of large and small point light source technology is adopted to enhance the hierarchical sense of media facade.

The control system of Shenzhen project adopts the international brand Osram control system, which is stable, reliable and flexible, and can centrally control the lighting facilities of the first and second bid sections of Futian Central District, including lighting, electrical, linkage control and cloud platform system. The communication mode is 4G + optical fiber + Internet of Things, and the network and communication terminal are provided by Huawei and Unicom. The control platform is compatible with multiple sets of subsystems, realizing centralized control and management, and providing a reliable platform for project operation and management [2].

2.1.3 Shanghai Hongkou North Bund city lighting linkage control case in 2019

Taking the North Bund landscape lighting improvement project in Shanghai Hongkou District as an example, the project is divided into four layers: "cloud, pipe, edge and end", which is conducive to the joint control effect and meets the requirements of intelligent detection and detailed management. The North Bund of Hongkou District is the core area of Shanghai, which has transformed the riverside night view of 2.5 kilometers away, with the theme of "The Bund heading north, sailing a new Shanghai", to ensure the harmony and unity of the connected area. According to the time and use needs, the mode is divided into normal mode, weekend mode, holiday mode and late night mode. The project makes full use of the old equipment, connects through the control system, and retains the lighting screens of multiple media facades to form a large-scale linkage scene. In the process of control system compatibility, the original control equipment has many brands and poor compatibility, which becomes the difficult pain point of the change.

The system combines the Internet + Internet of Things, cloud data analysis and other technologies to realize the intelligent and integrated management of lighting scenarios. The system is divided into four levels: "cloud, pipe, edge and end", where "cloud" is the control core, analyzing, managing and making decision on uploaded data, and establishing visual management center; "tube" is the network transmission layer, responsible for transmission from the cloud to the gateway; "edge" has preliminary computing power, screen and report abnormal information, and save network resources; "end" is the terminal, responsible for data collection, including lighting product control terminal, and light source and induction collector. The system also sets up three-level authority management: municipal, district and node control, and municipal institutions have unified and absolute command. The system is compatible with other smart platforms, such as traffic lights, cameras, urban environmental noise monitoring, etc. [3].

2.2 International Research Status

2.2.1 US city feel wireless sensor network project

Foreign smart lighting systems gradually evolve to the direction of open carriers, massive sensors and big data. In recent years, the NSFC has funded Harvard University and BBN to jointly develop a "city feel" wireless sensor network system based on municipal street lights. The system was first used in a lighting system in Kamanbridge, Massachusetts,

with sensors on street lights and a street light power supply system to power the operation of the sensors. These sensors form nodes in the city to send the detection content back to the detection center and provide massive data for experts and scholars[4].

2.2.2 Dutch "Twilight" adaptive lighting system project

The Dutch Twilight adaptive lighting system uses a similar intelligent lighting scheme to the "city feel" system. The "Twilight" system instsensors on the dense municipal lighting in the city, collects a large amount of mobile information from pedestrians, cyclists and cars, and automatically and flexibly adjusts the lighting brightness of pedestrians or vehicles, so as to achieve the goal of environmental protection and energy saving. Today, the installation of the "Twilight" adaptive lighting system has spread from several towns in the Netherlands to many cities in Ireland and India, integrating the concept of improving functional lighting quality, energy saving and emission reduction into the local lighting aesthetics [4]. (See Figure 1 and Figure 2)

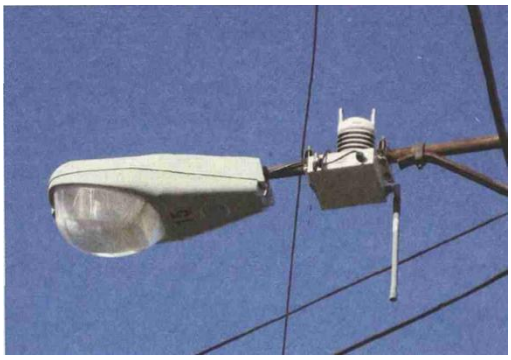

Figure 1 "City feel" street lamp in the United States[4]

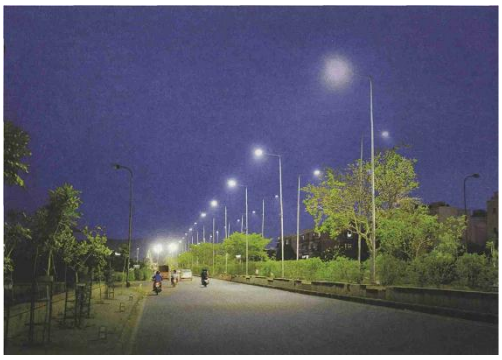

Figure 2 The Dutch Twilight adaptive lighting system[4]

2.3 Comparison Of Intelligent Control Systems Domestic and International

The development of lighting systems at home and abroad shows that the development process of functional lighting, landscape and art decoration lighting, indoor and outdoor space special lighting, green and energy-saving lighting to "light + N" breakthrough lighting engineering and application development, light and lighting is a history of technological innovation [5].

At present, the LED lighting market at home and abroad has entered a relatively mature stage, the future development trend is through the Internet +, big data, new technology applications such as artificial intelligence, form wisdom interconnection, wisdom lighting upgrade iteration and data driven, the whole chain of scientific lighting control system, strengthen the construction of urban lighting organic, fine management and industry high quality development.

2.3.1 There are different application areas of intelligent control system

Compared with foreign countries, China's current DMX512 control system is mainly used in urban landscape lighting, with large media facade linkage to show the city reputation, and is not used in the field of urban functional lighting. In foreign countries, due to the influence of political system and other factors, urban intelligent control system is mainly used in urban functional lighting, with linkage control of municipal street lights, emphasizing lighting function and other factors.

2.3.2 Intelligent control from the traditional SPI serial protocol to the unification of the DMX512 protocol

In this regard, there is a trend of replacing SPI serial interface technology with DMX512 protocol at home and abroad, which has great research value. Compared with the traditional SPI serial interface technology at home and abroad, DMX512 protocol is more widely used in the light control system at home and abroad. This protocol adopts point-to-point master-slave control system, and adopts multi-point bus structure in the interconnection form, there is no problem of information channel obstruction, and has high reliability [6].

The comparison between DMX512 protocol control system and SPI serial interface control system is shown in the following table 2.

Table 2 Analysis and Comparison of SPI SACS to DMX512 Protocol Control System

	Benefits	Defects
DMX512 protocol control system	1. Parallel structure of lamps, the damage of a single lamp will not affect the use of other lamps; 2. Simple implementation, do not need special hardware equipment support; 3. International standards are widely used abroad.	Single hole and single point design, the cost is relatively high.

SPI SACS	1. occupying less port, allowing one main device to start one slave device, saving cost and space; 2. Is mature and widely used in China.	1. The semiconductor components must comply with the original controller; 2. In the series system, the damage of one lamp will affect the use of subsequent lamps.
Trend summary	At present, DMX512 protocol control system is replacing SPI serial interface control system, and obtaining more and more application scenarios at home and abroad.	

3 ARCHITECTURE OF THE URBAN LANDSCAPE LIGHTING CONTROL SYSTEM

Reviewing the development process of urban landscape lighting and media facade lighting, in view of the difficulties in the development of intelligent control system, it is necessary to improve the system architecture to make it more adapt to the needs of smart city. This paper summarizes the idea of system architecture and improves, combined with the actual case problem, puts forward the thinking of urban landscape lighting control system architecture.

3.1 Three Main Functional Structures

From the perspective of the internal operation function of the system, the system consists of three parts: operation hardware and software entities, management behavior authority allocation and management behavior function. The operating hardware and software entities account for 40% of the total architecture, mainly including electrical facilities and equipment, application and maintenance technology, network functional equipment and software, etc. Electrical facilities and equipment include monitoring equipment and alarm equipment, application technologies include matrix soft jumper technology and self-start technology, etc. Each functional equipment is signal network construction facilities, including router, optical fiber network, Ethernet, wireless network, etc. Data function devices include data integration programs and data logging programs [7].

From the perspective of the internal operation function of the system, the system consists of three parts: operation hardware and software entities, management behavior authority allocation and management behavior function. The operating hardware and software entities account for 40% of the total architecture, mainly including electrical facilities and equipment, application and maintenance technology, network functional equipment and software, etc. The allocation of management behavior authority accounts for about 35% of the whole structure, mainly including management elements, management mode and the evaluation of management results. Management elements include landscape lighting, road lighting, building lighting and other contents that need to be managed. The management methods include multi-level management, authority management, etc., and the evaluation results include terminal big data analysis, asset analysis, etc. Functional components account for about 25% of the system share, with independent authority, scalability capabilities, and portable compatibility. The main contents include single light / single point independent control, loop switching function, light source dimming and other comprehensive control functions, and third-party port protocol control function [8].

3.2 Ecosystem Architecture

From the perspective of longitudinal extension, the management platform is an intelligent landscape lighting system based on computer, Ethernet, optical fiber and 5G networks. It goes from the link control center at the top to the touch device, light source lamp and other execution devices at the bottom, using various interface protocols such as DMX512, RDM and RS485.

From the perspective of horizontal extension, the execution equipment can realize the interactive synchronous operation and coordination of media laser performance, music fountain and media facade lighting show. It mainly uses 5G broadband network and dedicated optical fiber transmission equipment to coordinate the execution of each bottom terminal to realize the synchronous control of ultra-remote space. It is required that the feedback data signal should be transmitted to the control center platform to realize cloud synchronous coordination and synchronous execution.

At present, the multi-terminal management center platform has tablet computers and smartphones, real-time on-site monitoring and management functions. Fixed centralized control center equipment, portable platform and fixed management center constitute a centralized + marginalized collaboration mode, which helps to solve emergency problems at any time.

In the ecological control system, executive equipment such as street lighting, landscape lighting, multimedia lighting, laser projection and artistic water le face compatibility problems due to diversity, large number, environmental differences and technical obstacles. To solve this problem, protocols with strong general compatibility and easy expansion and upgrading, such as DMX512, C-BUS and DALI, are usually selected.

The system coordination function is completed by the management center, and its complexity depends on the difference and compatibility of the regional lighting system managed and controlled. For example, the core area of the city takes the basic control unit as the urban lighting system, including multiple lighting scenes, landscape scenes, street scenes and nodes, forming a large-scale comprehensive and complex scene. Therefore, the data information is huge in terms of

transmission and feedback. According to the field application, weather change and activity requirements, data need to be processed in coordinated operation to realize dynamic changes, such as peak and valley changes of electricity consumption, network signal congestion degree and data transmission rate, etc. The intelligent control management center is in the core position in the joint operation of the system, which not only involves the operation of large system, but also has problems such as data processing, abnormal feedback, synchronous monitoring information processing, abnormal alarm response mechanism, scheduling processing mechanism and routine data analysis, test and analysis.

3.3 Network, Security Technology System And Emergency Plan Framework

3.3.1 Platform information and technology security

The management unit shall abide by network security laws and regulations, formulate / revise security plans, implement confidentiality responsibility, and ensure that each post has a clear person in charge. For the system to establish a hardware firewall and software antivirus program double guarantee. Establish the backup mechanism of multiple machines and devices to ensure that when the host encounters a fault, attack or threat, the backup device can be replaced in time and provide operation guarantee. Set centralized hierarchical authority management, and set operation authority according to job responsibilities.

3.3.2 Early warning

Through the abnormal feedback system, the remote investigation of the involved area points, forming the abnormal document classification report, automatically repaired or reported to the management unit for on-site investigation. Quick response: Field patrol personnel can quickly determine the fault. Quick repair: repair the site problems in time.

4.OPERATION AND MAINTENANCE SYSTEM PLANNING

4.1 Daily Strategy of System Operation and Maintenance

Develop the information collaborative management and data exchange strategy of the control system to ensure the project stability. Record the fault items in the operation and maintenance management, and take the responsibility to the person in the form of work order. The data sources include the control platform software, audio and video monitoring platform and on-site inspection personnel, etc.

1.Confirm the equipment and software models, specifications and technical parameters with the owner unit, implementation unit, design unit, quality inspection unit and other related units. Coordinate with suppliers to conduct equipment commissioning, acceptance, training and maintenance.

2.Dynamic setting and preservation system management and equipment confidentiality password, timely report, not adjusted at will, quarterly / monthly update.

3.Regular data statistical report: summarize and analyze the platform data at monthly, quarterly and annual levels, and report to the management unit.

4.2 Safe And Environment Support

1.Network environment: To ensure the interconnection between the server and the terminal buildings of the urban landscape lighting project, the fiber optic network with sufficient bandwidth is used. At the same time, equipped with enough office space and computer equipment to ensure the communication between audio and video monitoring stations and monitoring server, and daily management of office station control center and terminal control carrier interconnection.

2.Software environment: According to the management requirements, it is necessary to install intelligent lighting intelligent control platform software and intelligent lighting video monitoring platform software on the computer in the operation and maintenance station, and conduct debugging and operation.

3.Management documents and operation and maintenance documents: The goal of management documents is to achieve controllable data analysis and improve the quality of management through storing and calling documents. Operation and maintenance documents include software and hardware specification documents, system management documents, feedback data storage documents, operation log documents, service quality control documents, etc. In addition, other documents and materials, such as fax, documents and external materials, are required.

5 SUMMARY

This paper studies the development history of urban intelligent control system, the application status at home and abroad, and the functions of urban landscape lighting control system architecture and operation and maintenance system planning and so on. On the one hand, based on literature research method, investigation comparison method and case study method, the comparison study of urban lighting control system at home and abroad, the development process of urban lighting control system is summarized, and the application comparison conclusion of urban lighting control system at home and abroad is put forward. On the other hand, by summarizing the problems existing in the urban lighting control system, and putting forward optimization measures, it provides cases and literature reference for the future application research of the urban lighting control system [9].

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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REFERENCES

[1] Wang Qin. Urban landscape lighting based on the smart lighting control system. Proceedings of the Chinese Lighting Society, 2017 (9 / 7): 410.
[2] Yuan Weiming, Li Minghai, Zhang Hui.Take the light show in the central area of Shenzhen on the 40th anniversary of reform and opening up as an example. Journal of Lighting Engineering, 2021,32 (04): 162-167.
[3] Zhou Na, Li Junyun, Yang Yun. Intelligent control system and its application of Urban Landscape Lighting based on the Internet of Things Technology- -Take the Landscape Lighting Improvement project of Hongkou North Bund in Shanghai as an example. Journal of Lighting Engineering, 2020,31 (05): 131-136.
[4] Liu Guowei. Environmental big data to play with the earth. Environment and Life, 2019, (138): 12-22.
[5] Hollosie. Light and Lighting under global Reconstruction: Hot spots and Trends, Changes and Countermeasures. Journal of Lighting Engineering, 2020,31 (06): 4-5.
[6]]Zhang Zhen, Chen Shan. LED product innovation design based on single-line parallel DMX512 technology. Baidu Scholar, 2015.
[7] Yi Junlin. Design and implementation of radio and television network based on GIS. University of Electronic Science and Technology, 2018.
[8] An Bin. Design and implementation of the Data network security management System based on SOC. Beijing: Beijing University of Posts and Telecommunications, 2009:72.
[9] Chao Daiquan, Yang Yongquan, Shi Yao. On the intelligent control of Landscape Lighting. Journal of Lighting Engineering, 2022,33 (05): 49-54.