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Prospects and Challenges of Intelligent Management of Fire-Fighting Facilities and Equipment under the Background of Smart City

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Abstract: Under the development wave of smart cities, intelligent management of fire-fighting facilities and equipment has become a key measure to improve the level of urban fire safety. This paper aims to deeply explore the prospects and challenges of intelligent management under this background. By using the methods of literature research and theoretical analysis, the relevant academic achievements and practical experience are widely collected, and the principle, technology and application of intelligent management are deeply analyzed. It is found that intelligent management shows broad prospects in improving the efficiency and accuracy of fire fighting, optimizing the allocation of resources and promoting the sustainable development of cities. However, there are also many challenges in technology, management and cost, such as inconsistent technical standards, data security risks, imperfect management system, personnel quality to be improved and high construction and operation costs. To sum up, a comprehensive understanding of the advantages and disadvantages of intelligent management of fire-fighting facilities and equipment under the background of smart cities is of great significance to promote its healthy development and better integrate into the layout of smart cities.

1. Introduction

In today's era of rapid development of science and technology, the construction of smart cities has become an important trend of global urban development. With the continuous innovation and wide application of information technology, cities are moving towards a more intelligent, efficient and sustainable direction [1]. Smart cities integrate all kinds of information resources to realize the interconnection and cooperative operation of urban systems, aiming at providing residents with a better living environment and enhancing the comprehensive competitiveness of the city [2]. As a key component of urban security system, the management level of fire-fighting facilities and equipment is directly related to the life and property safety of urban residents [3]. Under the background of smart cities, intelligent management of fire-fighting facilities and equipment came into being, which is not only an inevitable choice to conform to the trend of scientific and technological development, but also an urgent need to improve the level of urban fire safety [4].

It is of great practical significance to study the intelligent management of fire-fighting facilities and equipment under the background of smart cities [5]. On the one hand, intelligent management is expected to break through the limitations of traditional fire management mode, and realize real-time monitoring, intelligent early warning and efficient disposal of fire control facilities and equipment with the help of advanced technologies such as Internet of Things and big data, significantly improving the efficiency and accuracy of fire control work and building a solid defense line for the safe operation of the city. On the other hand, an in-depth analysis of the challenges faced in this field will help to formulate targeted coping strategies in advance, promote the healthy and orderly development of intelligent management of fire-fighting facilities and equipment, and make it better integrated into the overall layout of smart city construction.

This paper aims to comprehensively and systematically explore the prospects and challenges of intelligent management of fire-fighting facilities and equipment under the background of smart cities. It is expected that through this study, it will provide useful reference for relevant departments to formulate policies, enterprises to carry out practice and scholars to further study, and jointly promote the intelligent management of fire-fighting facilities and equipment to play a greater role in the construction of smart cities.

2. Smart city and intelligent management theory of fire control facilities and equipment

2.1. Smart city

Smart city is a new urban development model that uses information and communication technology to perceive, analyze and integrate the key information of the core system of urban operation, so as to realize the intelligent management and operation of the city [6]. Supported by the new generation of information technology such as Internet, Internet of Things and cloud computing, it closely connects people, things and information in the city, and enables the city to have the ability of self-perception, self-analysis, self-decision and self-adjustment.

Smart cities have the characteristics of comprehensive perception. With the help of various sensors and intelligent devices, all aspects of urban operation data are collected [7]. At the same time, it has the characteristics of interconnection, realizing data sharing and interaction among various systems and departments in the city through high-speed networks, and breaking the information island. Intelligent decision-making is also one of its important features. Using big data analysis, artificial intelligence algorithm and other technologies, the collected data are deeply mined and analyzed, which provides scientific basis for urban management decision-making and realizes intelligent and accurate management.

2.2. Intelligent management theory of fire control facilities and equipment

Intelligent management of fire-fighting facilities and equipment refers to the process of real-time and dynamic monitoring and management of the running state and maintenance of fire-fighting facilities and equipment relying on modern information technology. By connecting all kinds of fire-fighting facilities and equipment to the intelligent management system, automatic data collection, transmission and analysis can be realized, so as to find out the faults and hidden dangers of facilities and equipment in time and provide strong support for fire-fighting work.

Internet of Things technology is the basis of intelligent management of fire-fighting facilities and equipment. It connects sensors and equipment into a network, so that fire-fighting facilities and equipment can upload data in real time [8]. Big data technology stores and analyzes massive fire data, and explores potential fire risk patterns and operating rules of facilities and equipment. Artificial intelligence technology realizes intelligent early warning, fault diagnosis and intelligent

deployment of fire fighting resources through machine learning and deep learning algorithms, and provides intelligent decision support for intelligent management of fire fighting facilities and equipment.

3. Prospect of intelligent management of fire-fighting facilities and equipment under the background of smart city

3.1. Improve the efficiency and accuracy of fire fighting

Under the framework of smart city, with the help of Internet of Things technology, all kinds of fire-fighting facilities and equipment, such as fire detectors and fire hydrants, are equipped with intelligent sensors to realize 24-hour real-time monitoring. Once the abnormal situation is detected, the system can quickly and accurately locate and issue an early warning. Intelligent fire control system can not only give early warning in time, but also provide intelligent response and rescue assistance when a fire occurs [9]. By analyzing the data of fire scene and surrounding environment, such as building layout, personnel distribution, fire exits and so on, the system automatically generates the best rescue path and strategy by using artificial intelligence algorithm (as shown in Table 1). At the same time, it can also provide real-time images and data for firefighters, help them better understand the fire situation, make scientific decisions, and greatly improve the efficiency and accuracy of rescue.

Table 1: Basis for Generating Rescue Strategies in Intelligent Fire Protection Systems

Basis Factor	Specific Content	Data Acquisition Method	Impact on Rescue Strategy
Fire Location	Precise positioning data such as floor number, room number, etc.	Detectors, indoor positioning systems	Determine the direction of movement and target points, plan the quickest route
Building Layout	Floor plans, evacuation routes, fire compartments, etc.	Blueprint input, on-site survey updates	Judge fire spread, select attack and evacuation routes, allocate resources
Personnel Distribution	Areas of personnel concentration, numbers, and mobility capabilities	Cameras, sensors, and personnel information systems	Prioritize rescue of densely populated and special personnel areas, plan evacuation schemes
Fire Protection Resources	Locations and quantities of nearby fire hydrants, fire extinguishers, water tank levels, elevator status, etc.	Facility sensor feedback	Determine the priority of fire-fighting resources, ensure fire suppression, plan elevator usage
Meteorological Data	Real-time wind direction, wind speed, temperature, humidity, etc.	Interface with meteorological systems	Judge fire spread, adjust rescue strategies, such as setting up isolation zones, selecting smoke exhaust directions
Surrounding Road Conditions	Congestion levels, traffic control information	Data sharing with traffic departments	Plan routes for rescue vehicles, avoid congestion, facilitate rapid arrival at the scene

3.2. Optimize resource allocation

Intelligent management system can grasp the use and performance of fire control facilities and equipment in real time. According to the data analysis, the layout and deployment of facilities and equipment are planned reasonably to avoid the waste and idleness of resources. For some indispensable fire-fighting equipment with low utilization rate, centralized management can be carried out and quickly deployed to the corresponding areas when necessary. At the same time, according to the operation data of the equipment, the maintenance cycle and replacement time of

the equipment are predicted, and the resources are reserved in advance to ensure that the fire-fighting facilities and equipment are always in a good standby state.

Under the traditional fire management mode, a lot of manpower is spent on the daily inspection and maintenance of facilities and equipment. Intelligent management can automatically complete most of the data collection and preliminary analysis, freeing firefighters from tedious basic work and putting more energy into key tasks such as fire prevention and emergency rescue.

3.3. Promote the sustainable development of cities

Intelligent management of fire-fighting facilities and equipment, as an important link in the construction of smart cities, is integrated and coordinated with other intelligent systems in cities, such as traffic management and environmental monitoring. Through data sharing and interaction, we can realize the optimal allocation and efficient utilization of the overall resources of the city, promote the all-round development of smart city construction, and enhance the comprehensive competitiveness of the city.

Efficient intelligent management of fire-fighting facilities and equipment provides a solid security guarantee for the long-term and stable development of the city. By reducing the damage and impact of fire accidents on urban infrastructure, ecological environment, and residents' lives, cities can create a safer and more livable environment, effectively attracting more talent and investment, and ultimately promoting sustainable economic and social development.

4. The challenge of intelligent management of fire-fighting facilities and equipment under the background of smart city

4.1. Technical challenges

At present, there is no unified technical standard in the field of intelligent management of fire-fighting facilities and equipment. The devices produced by different manufacturers are quite different in communication protocols and data formats, which makes it difficult to be compatible between systems and effectively share data. As shown in Table 2, the differences in key technical parameters of common fire fighting equipment are visually presented:

Table 2: Technical Differences in Fire Protection Equipment from Different Manufacturers

Equipment Type	Manufacturer A	Manufacturer B
Fire Detector	Uses proprietary communication protocols, with data format in custom binary encoding	Follows some general protocols, but data format is in specific XML format
Fire Hydrant Pressure Sensor	Outputs analog signals, with a pressure range of 0-2.5MPa	Outputs digital signals, with a pressure range of 0-4MPa
Fire Alarm Host	Communication interface is RS485, supporting up to 256 device connections	Communication interface is CAN bus, supporting up to 128 device connections

With the improvement of intelligence of fire-fighting facilities and equipment, a large number of sensitive data are produced, and data security is facing severe challenges. Network hackers may attack the intelligent management system, steal the operation data of fire protection facilities and equipment, fire alarm information, etc., and even tamper with the data to cause misjudgment of the system. In addition, the illegal operation or data leakage of internal personnel may also cause serious consequences. For example, if the fire hazard data is maliciously deleted or modified, firefighters will not be able to grasp the real situation in time and delay the rescue opportunity.

4.2. Management challenges

The traditional fire management system does not adapt to the intelligent management mode. In intelligent management, it involves the cooperative work of many departments and links, such as fire department, information department and equipment maintenance enterprise, but there is no clear division of responsibilities and efficient coordination mechanism at present. Intelligent management has greatly improved the technical ability of firefighters. Firefighters should not only master traditional fire fighting knowledge and skills, but also be familiar with information technology, data analysis and other knowledge. However, at present, the professional and technical personnel in the fire brigade are relatively scarce, and there is a lack of a perfect training system. The existing training contents and methods can't meet the needs of intelligent management, which leads to that firefighters are not skilled in the operation and can't give full play to the advantages of the system when facing the complex intelligent system.

4.3. Cost level challenges

To realize intelligent management of fire-fighting facilities and equipment, high construction cost is needed. These costs mainly include hardware procurement expenses such as smart sensors, communication equipment, and data processing servers, as well as software implementation expenses such as system development and integration. In addition, the intelligent transformation of existing fire-fighting facilities and equipment also requires a lot of financial support. Taking a medium-sized city as an example, it is estimated that the cost of intelligent transformation and construction may be as high as tens of millions of yuan.

The operation and maintenance cost of intelligent system can not be ignored. System operation requires continuous power supply, and communication network leasing also requires regular payment. In order to ensure the stable operation of the system, it is necessary for professional technicians to carry out daily maintenance, troubleshooting and system upgrade, and the labor cost is high. With the upgrading of technology, the cost of replacing and upgrading equipment and software will also increase.

5. Conclusions

This paper focuses on the prospects and challenges of intelligent management of fire-fighting facilities and equipment under the background of smart cities. Intelligent management has brought about remarkable changes in the field of fire protection and achieved remarkable results in the future. Real-time monitoring and early warning functions make fire hazards invisible, intelligent response and rescue assistance greatly improve rescue efficiency, optimize resource allocation, and make more rational use of manpower and facilities and equipment resources. At the same time, the deep integration with smart cities and the long-term security of cities have effectively promoted the sustainable development of cities. However, it cannot be ignored that the road to intelligent management is not smooth. The lack of standards and data security risks at the technical level, system loopholes and personnel quality dilemma at the management level, and the high construction and operation and maintenance pressure at the cost level all restrict its further development.

Faced with these situations, in order to realize the good development of intelligent management of fire-fighting facilities and equipment, we should unify technical standards as soon as possible and build a data security protection system; Improve the management system, clarify the responsibilities of various departments, and strengthen coordination and cooperation. At the same time, relevant departments should establish and improve the training system to improve the professional quality of firefighters. In terms of cost control, it is necessary to explore a reasonable

investment and operation mode to reduce the construction and operation costs. Only by comprehensively dealing with these challenges can we give full play to the advantages of intelligent management in smart city fire protection and escort the safe development of the city.

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