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Research Article

Effectiveness Study of Artificial Intelligent Facility System in Maintaining Building Fire Safety (Case Study: Typical Public Building Cases of Fire-Fighting Facilities Management in China)

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Artificial intelligence plays a decisive role in the healthy and sustainable development of society. The rapid development of the economy and society has put forward higher standards and requirements for fire supervision. The development of science and technology has advanced the intelligence on fire protection. Through the application of intelligent fire control, the fire department can better supervise the fire control of various units and further improve the pertinence and effectiveness of fire control supervision. Artificial intelligence technology is widely used in all stages of construction projects, which brings many conveniences to the construction and use of projects. Based on the analysis of the current situation and existing problems of the basic maintenance of fire-fighting facilities, this project analyzes the effect of the application of artificial intelligence technology in the management of fire-fighting facilities. Therefore, the purpose of this project is to study the role and effectiveness of artificial intelligence technology in the management of fire-fighting facilities and further verify this conclusion with questionnaires and interviews.

1. Introduction

Building fire-fighting facilities refer to the general term of equipment and facilities set in buildings, such as automatic fire alarm system, automatic sprinkler system, and fire hydrant system to prevent and extinguish building fires. It is an important facility to ensure building fire safety and personnel evacuation safety, and it is an important part of modern buildings [1].

In the past 20 years, with the accelerating pace of urban construction and the rapid development of design and construction technology, various comprehensive buildings, high-rise buildings, super high-rise buildings, and other modern buildings have emerged one after another. While improving the quality of urban life and modernization level, they are also the main place for serious and especially mass casualty fire accidents [2]. The reasons are: on the one hand, the lack, failure, illegal shutdown of fire-fighting facilities, and other factors lead to the failure to achieve the fire performance required by the design; on the other hand, the complex internal structure of the building, diverse use functions, and occupation of fire passages are not conducive to fire fighting and rescue and even cause casualties of firefighters [3].

Due to the characteristics of large and comprehensive buildings, they mainly rely on the fire-fighting facilities inside the buildings to save themselves in case of fire. Therefore, it is necessary to ensure that these buildings keep the fire-fighting facilities intact and effective in daily operation [4]. In order to achieve the goal of complete and effective fire-fighting facilities, the relevant maintenance, supervision, and use departments can play a more effective role in fire prevention and extinguishing only if they are familiar with the design structure, functional layout, personnel distribution, fire-fighting facilities, and other professional information of the building [5].

Strengthening the management of building fire-fighting facilities, ensuring the integrity of fire-fighting facilities, improving the integration and intelligence of fire-fighting

facilities management in various buildings, and effectively improving the fire prevention and control ability are new topics in the fire safety supervision and management.

Artificial intelligence is a new comprehensive interdisciplinary subject developed on the basis of the complementation of multiple disciplines. It has gradually developed into the focus and research hotspot of various industries in society and plays a decisive role in the healthy and sustainable development of society.

In the field of construction engineering, artificial intelligence has been widely used in all stages of engineering projects, improving the refinement, digitization, intelligence, and informatization level of the engineering field in multiple directions and promoting the rapid development of the construction engineering field.

Therefore, this project believes that the application of artificial intelligence technology to fire-fighting facilities can innovate the fire management mode, improve the fire safety management level, and meet the application of large-scale and comprehensive buildings in fire prevention and extinguishing.

According to statistical analysis of the development of the construction industry in 2010–2021 [6], it reveals that with the continuous emergence of large comprehensive and complex buildings in China, fire safety is facing great challenges (Figure 1).

In China, public buildings are defined as buildings that provide users with public activities. Public buildings are urban civil buildings among civil buildings. In addition to the general characteristics of public buildings, large-scale public buildings have some new characteristics due to their large construction area and investment scale, mainly in three aspects.

1.1. Rapid Growth in Quantity. Public buildings are indispensable places for human work and life. With the rapid development of China's economy and the improvement of people's living standards, the demand for large-scale public buildings is increasing. According to the statistics of the National Bureau of Statistics (Figure 2), the construction area of public buildings in China has increased year by year, from 553.6304 million square meters in 2013 to 116.53021 million square meters in 2021 [7]. As China's urbanization has entered a stable development stage, urban construction has also entered a new wave. The proportion of large-scale public building construction area in the total construction area has changed from high-speed growth to stable growth.

1.2. High Economic Benefits. Since 2011, the added value of the construction industry has always accounted for more than 6.8% of GDP. In 2020, it hit another record high, reaching 7.2% and maintained growth for four consecutive years after declining for two consecutive years in 2015 and 2016. The status of the construction industry as a pillar industry of the national economy is stable [6].

These three characteristics of large-scale public buildings make people have higher and higher requirements for their use performance and the environment in the place. With the structural form of large-scale public buildings becoming more and more complex and the shape becoming larger and larger; therefore, in the process of building and putting into use, its facility management mode has a very important impact (Figure 3).

In the management of fire-fighting facilities, managers are a very important subject. We can see from the chart of employment in the construction industry in 2021 that the number of employees in the construction industry was 53.669 million, decreasing for two consecutive years. In 2022, there will be a decrease of 605000 people or 1.1% compared with the end of the previous year. In the past three years, with the continuous expansion of the production and operation scale of China's construction enterprises, the total output value of the construction industry has continued to grow, reaching 26.4 trillion yuan in 2021, an increase of 6.2% over the previous year [6]. The growth rate of the total output value of the construction industry increased by 0.6 percentage points over the previous year and increased after declining for two consecutive years [6]. The number of employees in the construction industry decreased, but the number of enterprises increased, and the labor productivity reached a new high.

It can be seen that the number of people engaged in low-end labor in the construction industry is gradually decreasing (Figure 4), while the facility system of public buildings is increasingly complex and the management difficulty is increasing, which indicates that the requirements for facility managers will change to high-quality and high-efficiency in the future, which requires the innovation of the entire facility management system as the foundation [6].

Therefore, fire prevention measures for large and complex public buildings are particularly important to avoid unnecessary hidden dangers of life and property. The probability of fire is increasing and the difficulty of fire prevention and control is increasing.

According to statistics (Fire and Rescue Bureau of the Ministry of Emergency Management, [8]), from 2012 to 2021, a total of 1.324 million fires in construction sites occurred in China, causing 11,634 deaths, 6,738 injuries, and direct property losses of 7.77 billion yuan. In 2021, a total of 748,000 fires were reported nationwide, resulting in 1,987 deaths and 2,225 injuries, resulting in direct property losses of 6.75 billion yuan. Buildings accounted for 34% of the total number of fires, with 254,000 cases, among which schools, hospitals, shopping malls, markets, hotels and restaurants, culture and entertainment, transportation hubs, large complexes, and other public buildings with dense personnel suffered relatively concentrated casualties. A total of 32,000 fires occurred throughout the year, killing 179 people and injuring 422. It is not impossible to imagine that the administration of fire safety in public buildings is of the utmost significance.

The new situation is testing the fire safety managers. The basic construction of fire safety cannot adapt to the rapid development of economy and society, the guarantee ability of fire safety cannot adapt to the safety needs of the people, and the public's awareness of fire safety cannot adapt to the modern management level. The State Council has put

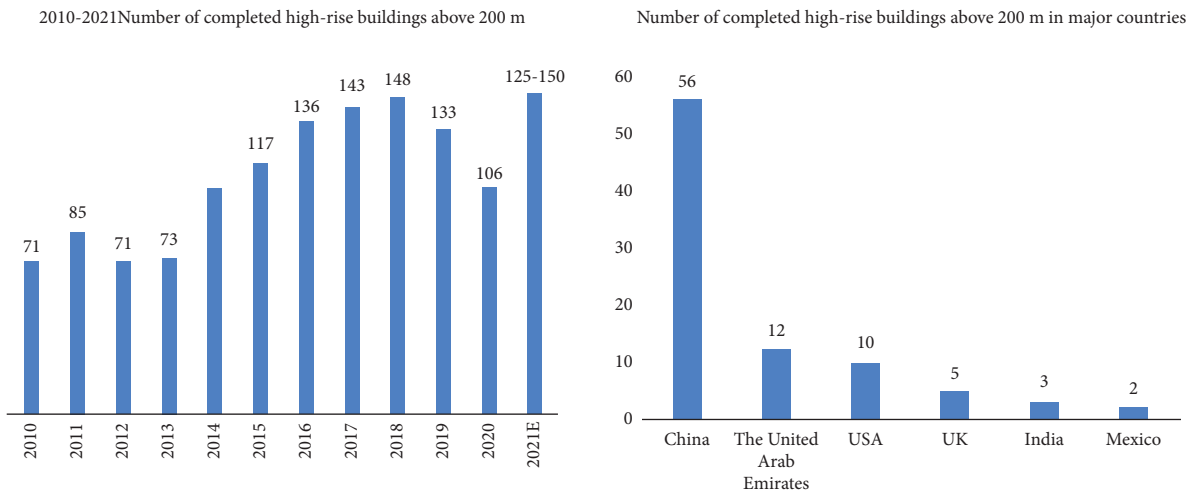

Figure 1: Statistical analysis of the development of the construction industry in 2010–2021 (2022). Source: National Bureau of Statistics (NBS) [6].

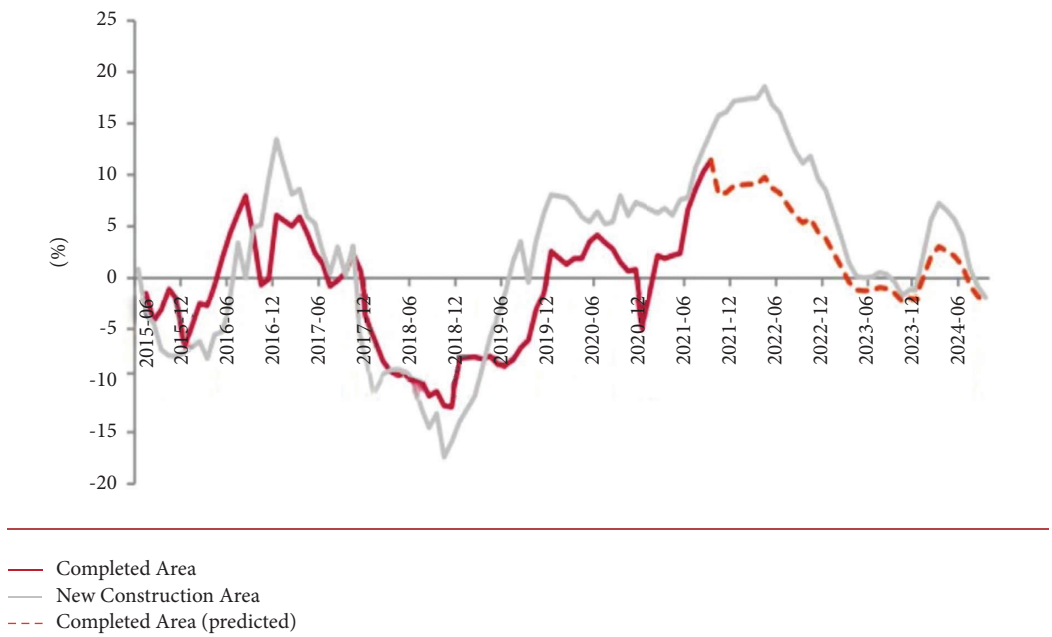

Figure 2: Growth rate of new construction area and completed area. Source: Zhongtai securities research institute, [7].

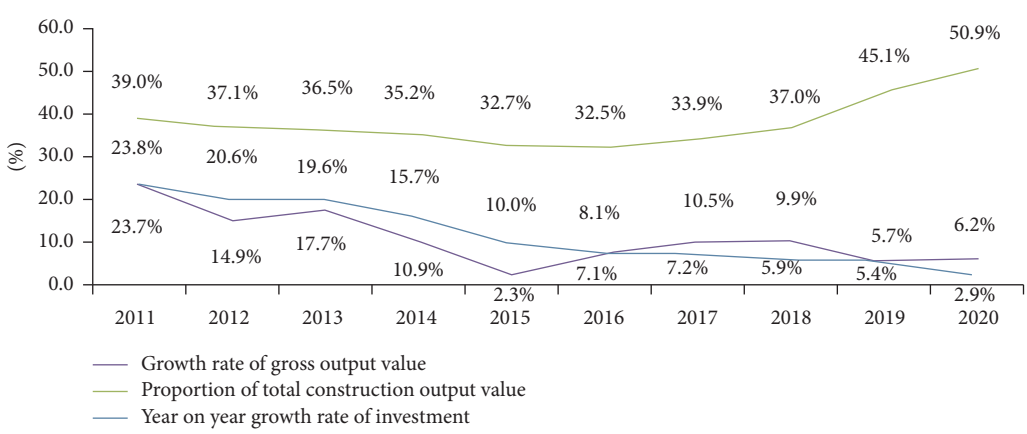

Figure 3: Gross output value and growth rate of construction industry. Source: National Bureau of Statistics (NBS) [6].

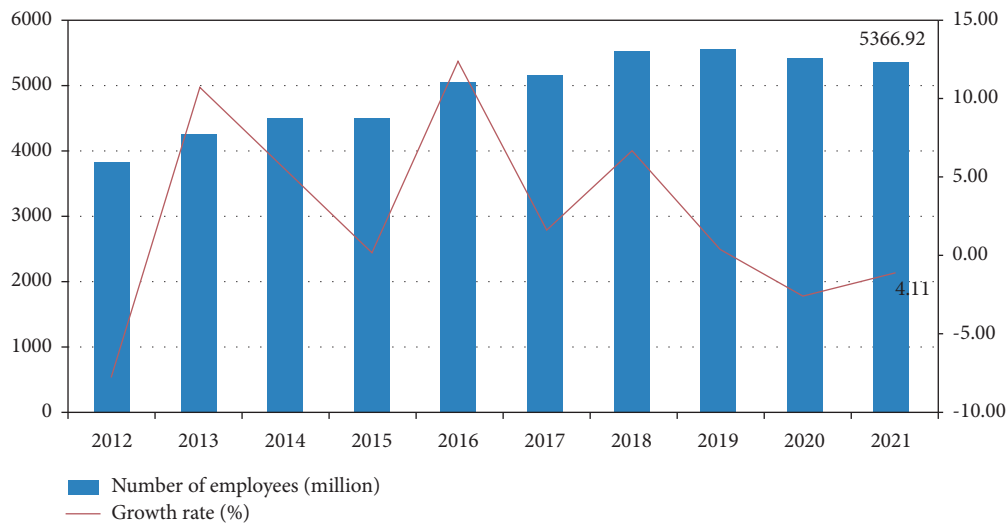

Figure 4: Growth of construction industry employees. Source: National Bureau of Statistics (NBS) [6].

forward the guiding ideology of "strengthening and innovating fire safety management" and "strengthening prevention." With the help of modern scientific and technological means, the fire safety management mode is changed and the fire safety management levelis improved (GOV) [8, 9].

China has stipulated different standards for different types of buildings in terms of fire safety management, and there are many regulations for building fire-fighting facilities [10]. However, due to the defects in the product quality and construction quality of fire-fighting facilities, some units have poor management in the maintenance of fire-fighting facilities, resulting in poor integrity and low operation rate of some fire-fighting facilities, resulting in the failure of effective utilization of fire-fighting facilities and the failure to play the role of fire prevention and extinguishing. The failure of building fire-fighting facilities to work effectively means that the building is not fortified, which is a major fire hazard.

In a word, the biggest problem in the management of fire-fighting facilities in China now is that the traditional fire-fighting management mode is inefficient and cannot adapt to the complex system of contemporary buildings.

Although this study is of great significance, there are still many problems in this study. First of all, the literature on the application of artificial intelligence in the field of construction is very rich, but it is rarely associated with the management of fire facilities [11]. Secondly, due to the short development time of the discipline of fire facility management and the limited application of artificial intelligence, the research reviewed by researchers has limitations. Therefore, it is necessary to check and confirm the data and literature sources and focus on the effectiveness of artificial intelligence in building fire management.

This project aims to study the effectiveness of the application of AI technology in the management of fire-fighting facilities in China. Other building services technology is inapplicable to this project. Secondly, this project mainly takes the domestic complex public buildings as the main research object, other building types such as residential buildings is not discussed as the main objects. Finally, the questionnaire of this study is distributed in the form of an online questionnaire.

2. Literature Review

2.1. Artificial Intelligence Adoption in Building Construction. The application of artificial intelligence in the field of construction engineering mainly includes three aspects: decision-making, construction, and operation [12, 13]. The decision-making process can be roughly divided into planning part and design part.

2.1.1. Decision-Making Process

(1) Planning. Using machine learning is a new way of learning. The focus of artificial intelligence is machine learning, which takes the previous data and experience as the basis and adopts reasonable methods and means to improve or optimize the algorithm. Artificial intelligence is used to deeply study the external environment, geological conditions, transportation, and other objective factors around the construction project and the big data of nearby human needs, and a new planning and design mode is established by combining the real scene technology of virtual reality [14]. Through this new planning and design mode, we can effectively avoid the risks that cannot be considered in the traditional mode, create a more green and healthy building environment, and realize the intelligent planning degree of construction projects in an all-round way [15].

(2) Design. Building information model (BIM) plays a very important role in the design stage of building engineering projects. BIM Technology is an efficient data-based auxiliary means for precise design, rapid construction, and visual management of engineering projects. This technology was first proposed by Professor Eastman of the Georgia Institute of technology in the 1970s. Using this technology in

construction engineering can improve the efficiency of engineering construction [16]. For example, Shanghai Center (the tallest building in China), Wuhan Center, and China Zun (the tallest building in the capital) all adopted BIM Technology in the construction process. In particular, after Shanghai center introduced BIM Technology in the construction process, the drawing design errors, project rework, construction period, and other aspects were reduced by 85%, 70%, and 15%, respectively, and the effect was extremely remarkable. Through visual 3D modeling, cloud computing, VR, and other technologies, it can effectively avoid design problems such as errors, omissions, collisions, and conflicts in various disciplines, reduce and optimize design costs, significantly reduce engineering changes and conflicts in the construction stage, shorten the construction period, reduce construction costs, and significantly improve the 3D visualization level of engineering project design results.

2.1.2. Construction. During the construction of construction projects, examples of artificial intelligence can be seen everywhere, such as 3D printing technology, and intelligent robots. 3D printing technology is a rapid prototyping technology based on a self-designed digital model program, which can be called a new industrial revolution. In the field of construction engineering, according to Wang et al. [3], the article summarized the research results of 3D printing technology related to architecture at home and abroad and summarized and classified the research results according to printing materials and processes. Through the application effect of this technology in construction projects, it can significantly improve the construction speed, reduce labor costs, save construction consumables, shorten the project duration, and realize green, healthy, and intelligent construction. At the same time, due to the R&D and upgrading of intelligent robots and their large-scale promotion and application, coupled with the rapid development of 5G technology and the characteristics of safety and reliability, intelligent robots with different functional types are designed, and they gradually replace manual operations in the construction process, such as bricklaying robots and unmanned excavators, which significantly improve the construction quality and save manpower and material costs.

In addition, artificial intelligence can be seen anytime and anywhere in the process of managing the construction site. Scholars such as Gao et al. [17] have made full use of augmented reality technology in the management process, and field managers can easily view the design plan, real-time progress, early budget, and other relevant information of the project at any place and at any time. At the same time, Ma and Wu [18] introduced the ISS system, which can quickly and efficiently make the main management personnel of the project clearly grasp the optimal project schedule based on the project objectives and constraints of a certain stage. Sowah et al. [19] used a target detection algorithm related to deep learning in the field of computer vision in the project. The on-site video captured by the construction site camera can automatically, quickly, and effectively identify whether the construction personnel wear safety helmets as required and can automatically alarm. With the comprehensive acceleration of the Beidou satellite navigation system in China, through the joint use of intelligent sensors and Beidou satellite navigation system, we can obtain the dynamic information of the construction site in real time, grasp all aspects of the construction site in a timely and accurate manner, ensure the efficient connection of all construction processes to the greatest extent, and timely find and solve the unexpected problems of on-site construction.

2.1.3. Operation. In the past 10 years, portable unmanned aerial vehicles equipped with high-definition omnidirectional rotating cameras have been widely used in many high-rise buildings, dams, bridges, and other related construction fields, showing an exponential development trend. In the construction project operation stage, intelligent methods such as UAV technology, visual algorithm, and deep learning algorithm can be fully used to dynamically predict and maintain the construction project products.

In the field of construction engineering, UAV technology derived from 5G has great potential and a huge market in visual monitoring of construction projects [20]. UAV can obtain ultraclear and high-precision video images within the monitoring range by carrying intelligent sensors of different functional types, generate dynamic and visual three-dimensional models in time, and get the traffic information around the project in real time, which can provide more accurate real-time information for relevant departments to quickly and efficiently formulate the best emergency disposal plan and improve the efficiency and success rate of emergency rescue. For example, the portable UAV carrying laser radar can quickly and efficiently obtain the three-dimensional point cloud of the surveying and mapping site by using laser surveying and mapping technology, so as to obtain the low-precision three-dimensional and all-round information about the surveying and mapping site. In the process of bridge monitoring, three-dimensional digital imaging technology and UAV can be comprehensively applied to real-time health monitoring [21]. During the outbreak of the epidemic in Wuhan, there was an urgent need to build Huoshen mountain and Leishen mountain hospitals. However, in order to prevent too many people from infecting Xinguan, 5g network and UAV technology were used for the first time in China to implement "cloud supervision" by using webcast. The joint supervision of the design, construction, and construction units of the project was successfully realized, and the method of off-site construction modules and on-site assembly was adopted, creating a new construction speed in China. Computer vision is to use the specific functions of the camera or computer to replace some functions of the human eye, identify, track, measure, and repair the predetermined target and maximize the effective information contained in it [22].

Deep-Learning is a new research field in machine learning, which aims to create and imitate the neural network of the human brain for analysis and study and analyze data by imitating the mechanism of the human brain

[23, 24]. Bao Yuequan and others proposed a method to judge the abnormal data of structural monitoring, which is mainly divided into three steps: the first step is to segment the real-time data that was originally continuously monitored; the second step is to image the segmented data (time-domain and frequency-domain responses) in two channels and label them in real time; the third step is to establish and optimize the deep learning algorithm to deep learn and determine the abnormal condition of the monitoring data. In order to verify the practicability and accuracy of the algorithm, through the analysis of acceleration data of a super long-span cable-stayed bridge, the monitoring and judgment results are compared and verified, and the balance and probability of the data set and other influencing factors are fully considered. The verification results are very good. It is proved that this technology algorithm can quickly and effectively distinguish the abnormal conditions of different kinds of data, and its development potential and application prospect are huge.

Su et al. [21] summarized the relevant research of the Los Alamos laboratory on machine learning in the field of artificial intelligence. Li et al. [25] Classified and summarized the relevant machine deep learning algorithms in the field of construction engineering and concluded that machine deep learning has a great application prospect in this field. Park et al. [26] used genetic algorithm, convolution depth learning, BP neural network, and other methods, combined with the actual data monitored by the construction project, through MATLAB software to iteratively calculate the prediction results of different models. After comparing with the actual monitoring data, they found that the prediction model based on the depth learning algorithm has the smallest error compared with other models, in other words, its prediction effect is the best.

There are many kinds of artificial intelligence algorithms with obvious advantages and disadvantages. We must select the appropriate algorithm for specific projects and further optimize the algorithm. Predicting the future data development trend based on the existing data development trend can not only greatly save labor but also provide a new way for the project prediction and early warning mechanism in the field of construction engineering [1].

2.2. Intelligent Fire-Fighting Facilities Management. Su et al. [20] using web, Ajax, and other information technology, combined with the actual situation of the building, developed a set of suitable applications of fire facilities management system, to achieve the informatization and standardized management of fire safety work and improve the level and efficiency of fire safety management.

Based on the combination of data mining, data analysis, and accident analysis theory, Zhang et al. [1] use the business intelligence component of Microsoft SQL server to perform data mining and implement the fire accident cases and data analysis with four commonly used algorithms: cluster analysis, association rules, time series, and decision tree. Data mining aims to provide a reference on the application methods in the analysis of incidents and has certain academic value and practical significance for data processing and information analysis of fire accidents.

The application of big data in the management of fire-fighting facilities has innovated the management system of fire-fighting facilities, expanded the effective methods of fire-fighting social governance, promoted the standardization of fire-fighting facilities management, and achieved dynamic fire-fighting management, intelligent fire-fighting information, autonomous learning forms, and maximized return on investment.

Shokouhi et al. [27] mentioned that building fire protection facilities refer to the man-machine system in a fixed engineering form composed of several fire protection products in a building, which is the general name of facilities used for fire alarm, fire, personnel dispersion, fire separation, fire fighting, and rescue operations. The reliability of building fire-fighting facilities refers to the degree to which building fire-fighting facilities can complete a specific set of fire-fighting tasks under specified conditions and within a specified time. This reliability includes the requirements of availability, credibility, and effectiveness. The reliability value of building fire-fighting facilities is an important basic data in building fire risk assessment (FRA). Later, this project will use this evaluation standard for comparative research.

Liu [28] researched how to overcome the delay of traditional fire control decision-making systems by using a novel module design of a visual fire-fighting decision-making system based on artificial intelligence. The module design combines the artificial intelligence technology and the latest communication technology to enhance the information communication efficiency between the fire field and the outside. The results show that the module design can promote the coordination and development of the four modules and then improve the accuracy of the fire decision-making system and provide a great convenience for firefighters.

2.3. Table of Gaps in the Literature. Table 1 shows the summary of the details of several representative literatures such as year, author, title, methodology, and conclusion.

Therefore, through this project, it is expected to close the research gap through the research on the necessity of applying artificial intelligence to the management of fire-fighting facilities.

3. Methodology

We expand the research on relevant research to have an in-depth understanding of the phenomena investigated and evaluate the availability of existing theories and models directly related to situations or facts that may change over time. Due to the gap between ideas and practical practices in the workplace, this section will explain the need for academic research. The research design, questionnaire design, and measurement table presentation of this study will be divided into three parts. Finally, the two cases are compared to compare their efficiency differences.

Table 1: Gaps table.

Year	Author	Title	Methodology	Conclusion
2012	Dake Zhang	Application of data mining techniques in the analysis of fire incidents	Literature analysis, relevant data collection	The effective role of big data technology in artificial intelligence technology in a fire emergency
2018	Hu Junjian	Discussion on the application of big data in the management of fire-fighting facilities	Distribution and literature analysis	Management role of big data technology in fire prevention
2019	Du Yulong et al.	Research status and thinking on reliability management of building fire protection facilities	Questionnaire distribution	The achievements and problems of the research on the reliability management of building fire-fighting facilities are closely related to its social development environment

3.1. Research Design. According to the purpose of this project, the study design is divided into four categories: descriptive, relevant, quasiexperimental, or experimental. However, there is no general consensus or criteria for classifying or grouping study designs into a prescribed number of categories. Each of the four major study designs has a series of characteristics that are different from other study designs. In addition, researchers may need to develop or include certain design elements in the study to answer research questions, test hypotheses, or control variation [29].

The data collection methods and data analysis methods used in the survey are mostly quantitative research, supplemented by some qualitative research. The quantitative part is primarily a questionnaire survey and secondary data analysis, and the qualitative research part is field research and in-depth interviews.

Select two public buildings as the research object for comparative analysis. At the same time, through the research literature analysis, artificial intelligence technology can be applied in the field of fire facility management to prove its effectiveness.

The interview (Appendixes A–C) was conducted in a one-on-one manner, and a total of three managers and a professor of artificial intelligence were selected. The questionnaire was conducted online. 50 questionnaires were distributed to each public building to collect employees' opinions on the existing fire management system (Table 2).

This study takes the management of fire-fighting facilities as a constant and AI technology as a variable to explore the effectiveness of the application of AI to the management of fire-fighting facilities.

The auxiliary analysis methods of this project include studying and analyzing similar cases of facility management in the domestic construction industry, and on this basis, issuing questionnaires to the project owners, operating companies, facility management, and other relevant principals, and analyzing the actual data recorded in the work log.

3.2. Data Collection and Analysis. The data collection is divided into two parts: respondents' behavior research and respondents' attitude research. Behavior research is mainly conducted through interviews, and attitude research is conducted through questionnaires.

The analytical methods of qualitative research are listed in Table 3.

The analytical methods of quantitative research are listed in Table 4.

The main qualitative analysis method used in this study is thematic analysis. The interviewer formulates thematic questions and asks the interviewees purposefully to obtain effective interview records. The main quantitative analysis method is survey analysis. Through random questionnaire survey and field survey data collection of specifically selected groups, the basic quantitative data are obtained as the database of the study.

3.3. Sampling Technique. When designing a sampling survey, what we usually do is to define the population and sampling unit, determine or construct the sampling frame, select the sampling technology, determine the size of the sample size, formulate the implementation details, and implement the road. This part briefly introduces the sampling methods and sample size of quantitative research [30]. The most basic sampling methods of quantitative research are divided into two categories, one is nonprobability sampling and the other is probability sampling. Nonprobability sampling is mainly used in this study. Nonprobability sampling cannot calculate sampling error because it is based on the judgment of the investigator, including random sampling, judgment sampling, and quota sampling [31].

In this study, the random sampling and judgment sampling in nonprobability sampling are selected. Street interviews and questionnaires are common in random sampling. Random sampling is the least costly and time-consuming of all samples. Sampling units are accessible, easy to measure, and cooperative [32]. Despite its many advantages, this form of sampling has serious limitations. There are many possible selection biases, such as the self-selection of the respondents and the subjective bias of sampling. Judgment sampling is based on the understanding and experience of the investigators on the whole, and representative and typical units are selected from the whole as samples. For example, several advanced, intermediate, and backward enterprises are selected from all enterprises as samples to investigate the operation status of all enterprises. If the judgment is accurate, it is possible to obtain well-representative samples by this method.

The project selects two typical enterprises representing traditional fire-fighting facilities management and intelligent fire-fighting facilities engineering, and several managers of the two enterprises were selected for interviews.

Table 2: Case study form.

Name	Number of questionnaires	Interviewee	Classification
Shenzhen library	50	Managers and employees	Traditional fire-fighting facility management condition
North university of China's library	50	Managers and students	Intelligent fire-fighting facility management condition

Table 3: Qualitative research data analysis method.

Method	Usage scenarios
Content analysis	Describe and classify common words, phrases and ideas in qualitative data
Thematic analysis	Identify and interpret patterns and topics in qualitative data
Text analysis	Check the content, structure, and design of the text
Discourse analysis	Study communication and how to use language to achieve results in a specific environment

Table 4: Quantitative research data analysis method.

Method	Usage scenarios
Experiment	Control or manipulate an to measure its effect on a dependent variable
Survey	Ask questions of a group of people in person, over-the-phone, or online
(Systematic) observation	Identify a behavior or occurrence of interest and monitor it in its natural setting
Secondary research	Collect data that has been gathered for other purposes e.g., national surveys or historical records

3.4. Sample Size Estimation. The size of the sample size involves the number of people or units to be included in the survey. It is a complex problem to determine the size of the sample size. Both qualitative and quantitative considerations are required.

The size of the sample size is considered qualitatively. The factors considered include the importance of decision-making, the nature of investigation, the number of variables, the nature of data analysis, the sample size used in similar studies, the occurrence rate, the completion rate, and the resource constraints. Specifically, more important decisions require more information and more accurate information, which requires a larger sample. The sample size of exploratory research is generally small. In order to reduce the cumulative effect of sampling errors, the sample size of data collected on many variables should be larger. The specific determination of sample size should also refer to the corresponding statistical formula. The goal of the sampling survey is to obtain acceptable accuracy and expected confidence level at the minimum cost. When we want to carry out a sample survey, no matter how its design is set, we must always find out how much it costs to survey and how many people, so as to meet the statistical efficiency we need for this research, so as to explain our research results convincingly. Therefore, we need to estimate the approximate sample size [33].

First of all, we need to know what factors will affect the sample size of the sampling survey.

Specific requirements for subsequent analysis methods are as follows:

① Acceptable accuracy

② Sample heterogeneity

③ Sample accessibility

④ Sampling techniques used

In other words, when determining the sample size required for sampling, we need to consider the impact of the above five factors. For specific research requirements, specific adjustments according to specific circumstances should be made. Generally, when calculating the sample size, it should follow the following formula:

$$n = \frac{z^2 \bullet p \bullet (1 - p)}{d^2}. \tag{1}$$

Among them, the z determines the confidence level, and the z value is generally 1.96 corresponding to 95% confidence level; p is the percentage of a feature in the target population. If there is no previous data, it is generally set to 0.5; d is the acceptable precision/accuracy level, generally we take 0.05.

For a sampling survey on the existing fire management system, this study does convention sampling and determines the 95% confidence level. Assuming that 90% of the target population are familiar with the management of fire facilities, the acceptable accuracy level is taken as 0.09. Therefore, for this survey and research, we need to calculate the sample size through the formula at least:

$$n = \frac{1.96^2 \bullet 0.9 \bullet 0.1}{0.09^2} \approx 42. \tag{2}$$

The results showed that at least 42 questionnaires were distributed. In order to facilitate classification, 50 questionnaires will be distributed in the two companies for further quantitative analysis.

3.5. Questionnaire Design. The questionnaire survey is divided into two parts, one is the survey of traditional fire-fighting facilities and the other is the survey of buildings using artificial intelligence technology. In the first part, we collected data from the above-given three groups by means of a field survey, questionnaire survey, and field visit. In the second part, we mainly use the methods of online data collection and online interviews. Finally, the results are analyzed and compared, and a conclusion is drawn.

Because the management of fire-fighting facilities is an important part of the construction operation and maintenance stage, we extracted three main groups: owners, operators, and suppliers. Each group has different responsibilities and different perspectives, which helps to make the questionnaire results comprehensive. Considering the research purpose, the interview mainly selects owners and operators. Table 5 shows the target population.

In this study, we divide the research object into three parts: constant, dependent variable and independent variable, which correspond to fire facility management, facility management link and artificial intelligence technology respectively. This study obtains the information of three parts through interviews. The research methods are summarized in Table 6:

3.5.1. Traditional Fire-Fighting Facility. The research on facility management in China is still in its infancy, and the management of fire-fighting facilities is in the operation and maintenance stage of buildings, which is the longest and most expensive stage in the whole life cycle [34]. Because the management mode and technology of fire-fighting facilities in China are relatively backward, there are many problems in management, so it can not be effectively managed. It mainly includes the 4 aspects: integrity of fire-fighting facilities, configuration of fire-fighting facilities, hidden dangers of fire-fighting facilities, and relevant data of fire-fighting facilities.

Due to the epidemic and the principle of proximity, in this project, Shenzhen Library, a traditional public building in Shenzhen, was selected for field investigation, and the staff were contacted to obtain the current situation information of all links of fire-fighting facilities. There are two ways to obtain information: one is to conduct an in-depth interview with a fire facility management manager and the other is to conduct a questionnaire survey on the staff responsible for each link (Appendix C).

3.5.2. AI Fire-Fighting Facility. In order to compare the new facility management mode with the traditional facility management to verify whether the addition of artificial intelligence can improve the efficiency of fire facility management, this study combines qualitative research and quantitative research methods in artificial intelligence fire management. Taking Li'an technology company, a domestic technology company dedicated to intelligent fire protection, and the fire-fighting facility system of the public library in North China University designed by this company as an example, a facility manager managing the library and a manager of the technology company were selected to interview the operation status of fire-fighting equipment, and 50 employees were selected to conduct a questionnaire survey on the fire-fighting management system (Appendix C).

3.5.3. Contrastive Study. In order to make the comparative research results more professional, this project interviewed a scholar who studies the direction of artificial intelligence, discussed some core technical issues, and verified whether the intervention of artificial intelligence can improve the efficiency of fire management.

3.6. Summary. In conclusion, the research methods are summarized into three tables at the end of this section: research design table, questionnaire table, and field questionnaire. The study provides top-down quantifiable data that can be used to draw inferences about the phenomena investigated. This section records all the methods used in this study and the assumptions set in future chapters.

4. Result and Discussion

This section shows the questionnaire, interview results, and questionnaire data of qualitative and quantitative analysis. It shows that in terms of fire supervision and the operation and maintenance of fire-fighting equipment, the use of artificial intelligence equipment has improved the efficiency and accuracy of manual management, but there are still deficiencies in the training and implementation of artificial intelligence system at this stage.

4.1. Results Summary. In the research, we adopted a combination of qualitative research and quantitative research, mainly quantitative research. We used the method of issuing questionnaires to obtain basic data, and the nondiscriminatory sampling method is to prove that the data is more universal. Qualitative research is used as auxiliary research, which is realized through interviews and field surveys with managers and managers.

The interview and questionnaire on the management of traditional fire-fighting facilities are focused on three parts: (1) quality training of management personnel, (2) supervision of fire-fighting facilities, and (3) operation and maintenance of fire-fighting facilities. The purpose of the questionnaire survey is to obtain the overall satisfaction of employees, and the purpose of interviewing professionals is to specifically analyze specific problems. The field visit can verify the authenticity of the questions in the interview, so as to obtain more authentic and reliable research conclusions. Through the study of these three aspects, we find that the traditional facilities management methods have great loopholes in the supervision,

Table 5: Survey target population.

Subject	Information obtained
Owner	(1) Owner's operation records (2) Photos and diagrams of the owner about the operation of fire-fighting facilities (3) Video and audio documents of the owner about the operation of fire-fighting fa cilities (4) Fire fighting facilities operation report
Operator	(1) Basic attributes of buildings, facilities and equipment (2) Contract text of fire-fighting facilities and equipment (3) Economic information of fire-fighting facilities and equipment (4) Maintenance information of economic information of fire-fighting facilities and equipment
Supplier	(1) Contract text of fire-fighting facilities and equipment (2) Economic information of fire-fighting facilities and equipment

Table 6: Interview design table.

Section	Variable	Items	Sources
A	Fire-fighting facility system	2	A community library's manager in Shenzhen/a manager of North University of China's library
B (independent variables)	Traditionally fire-fighting facility/ artificial intelligence adoption	2	Wang Hongwei, interview on July 10,2022, professor of artificial intelligence at Huazhong University of Science and Technology/Mr. Yao, a manager in a Chinese emerging artificial intelligence technology company
C (dependent variables)	Personnel management and training	2	A community library's manager in Shenzhen/a manger of North University of China library
	Supervision of the fire-fighting equipment	2	A community library's manager in Shenzhen/a manger of North University of China library
	Operation and maintenance of fire-fighting equipment	2	A community library's manager in Shenzhen/a manger of North University of China library

operation, and maintenance of fire-fighting facilities. Because the traditional management methods do not require high-quality of employees, the cost of staff quality training is low, and it also has a negative impact on the development of the entire facilities management.

The interview and questionnaire survey on the management of artificial intelligence fire-fighting facilities have taken into account the discussion of the above-given three aspects and the satisfaction survey of the intelligent platform. Since the application time of the intelligent platform is relatively short, the satisfaction survey of the platform can collect the acceptance of most employees for the involvement of artificial intelligence technology in the management field. Since this part of the interview adopts the online interview method, therefore, the assistance of the questionnaire is helpful to verify the authenticity and reliability of the interview and better compare with the traditional fire-fighting facilities management methods. The research shows that, on the whole, employees have a positive attitude towards the introduction of artificial intelligence platform, and the company's data prove that new technologies can promote the improvement of management efficiency. The following are detailed data and comparative analysis.

4.2. Content Analysis. In this part, we will show the interview results of two typical cases selected in this study (Figure 5), one is the interview with the managers in Shenzhen Library and the other is the interview with the managers in Zhongbei university library. Through the interview, we can deeply understand the management status of the internal fire-fighting facilities of the two typical public buildings. However, this part of the content has certain subjectivity, and due to limited sampling, it can only be used as a reference for subsequent analysis.

4.2.1. Case Study: A Community Library in Shenzhen. Shenzhen Library, formerly known as Bao'an County Library, was completed and opened in 1986. It is one of the "eight cultural facilities" in Shenzhen. In 2006, the new museum in the central area was completed and opened. It is located in front of the beautiful lotus mountain in the administrative and cultural center of Shenzhen, covering an area of 29600 square meters, with a total construction area of 49500 square meters and a total collection of more than 10 million books. It is one of the important public buildings in the city, with dense crowds and complex functions. Fire safety is particularly important.

This part selects Shenzhen Library as the research object to study the management of existing fire-fighting facilities. The research methods are mainly field survey, interview, and questionnaire survey, supplemented by literature research and online data search. This study selects a manager of a community library for in-depth interview. The form of interview is an offline interview. We selected a facility management manager for an interview according to the responsibilities of the manager and compiled the following

Figure 5: Survey photos.

table according to the interview content and field survey (Table 7).

Summary of Findings (Table 8):

(1) The initial installation does not meet the requirements

(2) The equipment is damaged, the maintenance is not in place, and some alarm functions cannot function normally

(3) The products have not been tested, the responsibilities of management personnel are unclear, and the management is not in place

Summary of Findings (Table 9):

(1) There is a lack of technical measures for fire protection, and the equipment startup process is obsolete

(2) The operation and maintenance personnel are derelict, fail to test and operate the equipment in time, and the cleaning and sanitation management is not in place, which affects the service life of the equipment

(3) Manual management is negligent, and false alarms occur frequently when there is no management

Summary of Findings (Table 10):

(1) The fire extinguishing system cannot flexibly respond to emergencies.

(2) The maintenance structure was not replaced in time.

Summary of Findings (Table 11):

(1) The monitoring and management on the evacuation exit are not in place

(2) The fire-fighting facility system is not separated from other systems

4.2.2. Case Study: The Library of North University of China. This part takes Zhongbei University as the research object to study the advantages and disadvantages of artificial intelligence fire-fighting facilities. The research methods are mainly interviews and questionnaires, supplemented by literature research and searching network data. The intelligent fire-fighting system used by North China University is developed by Li'an technology company (Figure 6). This study selects a manager of the school library and a manager of Li'an technology company for in-depth interviews. About the professional problems of artificial intelligence technology, this study interviewed Professor Wang Hongwei of Huazhong University of science and technology. Due to the impact of the epidemic, all interviews were conducted online.

The Campus Library covers a large area and there are many people entering and leaving, which makes it very difficult for the management unit to inspect and maintain the fire-fighting facilities on a daily basis. The traditional inspection and maintenance work adopts manual and handwritten filling, which consumes manpower and is prone to problems such as inadequate inspection, lack of fire-fighting facilities management, and blank supervision.

Using the mobile app application, upload the inspection results online, generate electronic files, and analyze the data intelligently, so as to reduce the labor cost and improve the inspection efficiency. At the same time, relevant data and archives of fire-fighting equipment and facilities can be queried online to improve management efficiency and ensure that fire-fighting equipment and facilities play their due role. The whole process can be queried digitally to solve the problem of lack of supervision.

Apply mobile app, upload inspection results online, generate electronic files, analyze data intelligently to reduce labor costs, and improve inspection efficiency. At the same time, relevant data and archives of fire-fighting equipment and facilities can be queried online to improve management efficiency and ensure that fire-fighting equipment and facilities play their due role. The whole process can be queried digitally to solve the problem of lack of supervision (Table 12).

4.2.3. Comparison of Both Traditional and AI Fire-Fighting System (Table 13). To sum up, the use of artificial intelligence technology in the management of fire-fighting facilities can indeed improve the work efficiency of fire-fighting early warning, maintenance of fire-fighting facilities, and daily records of fire-fighting facilities.

4.3. Questionnaire Feedback. We have prepared 50 paper questionnaires and 50 online questionnaires, which were distributed to the owners, operators, and suppliers of the two libraries. 47 online questionnaires were finally recovered, and 2 of them were not included in the scope of the study

Table 7: The problem of automatic fire alarm systems (source: author).

Functional items	Specific problem performance
Fire detector	(1) The model selection does not conform to the site, and the installation is not firm (2) The installation position, spacing, and inclination angle do not meet the specifications and design requirements. (3) The confirmation light of the detector is not facing the main entrance direction that is convenient for personnel to observe (4) The detector code does not correspond to the controller display and cannot reflect the actual position of the detector (5)The alarm function is abnormal
Manual fire alarm but ton	(1) The alarm function is abnormal, and the alarm address code does not correspond to the display of the controller, which cannot reflect the actual position of the alarm address (2) The installation is not firm and does not meet the specifications and design requirement
Fire display panel	(1) The installation does not meet the requirements, the wiring in the cabinet does not meet the requirements, and the power supply and grounding form of the fire alarm controller do not meet the requirements (2) The eight basic functions of the fire display panel do not fully meet the requirements, and the power capacity and power performance tests are unqualified
Fire alarm controller	Products without national quality certification are not selected. The installation and wiring do not meet the requirements, the power supply and grounding form of the fire alarm controller and the setting of the isolator do not meet the requirements, the 13 functions of the controller cannot be fully realized, and the stand-by power capacity and power performance test are unqualified
Grounding protection	The system operation and protective grounding do not meet the requirements
Fire linkage control e equipment	The products without national quality certification are not selected, the installation on and wiring do not meet the requirements, the 13 basic control functions do not fully meet the requirements, and the power capacity and electrical performance tests do not meet the requirements
System wiring	Wiring does not meet requirements

Table 8: The problem of automatic fire-extinguishing sprinkler systems (source: author).

Functional items	Specific problem performance
Water supply facilities	(1) The effective capacity of the fire pool is small, and there is no division measure for the pool with a large capacity (2) The flow of the fire pump is too small or the head is too large. A group of fire pumps has only one suction pipe or only one outlet pipe. There is no pressure gauge on the outlet pipe, no test drain valve, no pressure relief valve, the water diversion device is set incorrectly, the diameter of the suction pipe is too small, and the common water pump is mixed with the fire pump (3) The distance between the water pump adapter and the water intake of the fire pool is greater than 40 m, the number is relatively small, and it is not set in zones (4) The materials of the shared water tank on the roof of the fire water tank are the same as those of the fire pipe network, and there are no special measures for fire water (5) Fire hydrant pipe: small diameter, galvanized pipe, easy to rust, causing water leakage (6) Fire hydrant button: the button cannot directly start the water pump but can only start the fire pump through the linkage controller. After the button is started, there is no confirmation signal, and the button cannot alarm and display the position
Voltage stabilizing system	The flow of the pressure stabilizing valve is too large, the position setting of the pressure stabilizing valve does not meet the requirement, and the setting of the pressure-reducing device does not meet the requirements
Wet alarm valve	The location is inappropriate, and the water supply control valve is not set
Water flow indicator and water pressure	The signal valve is not installed in front of the water flow indicator or the distance from the water flow indicator is less than 300 mm. The tube diameter of the end test device is less than 25 mm. During the system linkage test, the end test valve is opened and the reading of the pressure gauge is less than 0.049 MPa
Other equipment	(1) The nozzle selection does not meet the requirements and is close to the high-power heating lamps (2) The pressure relief valve is not installed on the outlet pipe of the water pump. In some installations, the pipe network was not flushed and pressure tested as required (3) Some pipe joints have a water leakage and some pipes have debris, which is easy to block the nozzle. The gap between the casing and the pipeline is not filled with relevant materials. The pressure switch and hydraulic alarm bell give false alarm

Table 9: The problem of the fire-extinguishing gas system (source: author).

Functional items	Specific problem performance
Enclosure structure	Insufficient compressive strength of enclosure components
Linkage function	In case of fire, the linkage control of the gas fire extinguishing system cannot close the opening. Stop the fan and other functions, and do not close the smoke exhaust facilities
Equipment installation	The installation position and spacing of nozzles do not meet the design requirements

Table 10: The problem of preventing firebox off system (source: author).

Functional items	Specific problem performance
General control functions	Fire detectors are not set on both sides of the fire roller shutter used on the evacuation passage, and manual control buttons are not set on both sides. The feedback signal after the action of the fire shutter cannot be displayed in the fire control room
Control requirements for fire separation	The fire shutter used as a fire separation in the same fire compartment did not fall to the bottom after the fire detector acted, and the commissioning was not carried out according to the requirements of simultaneous action of the fire layer and the upper and lower layers
Fire power supply	The fire shutter control device is not powered by the fire power supply
Fire resistance	Single piece roller shutter without water curtain protection
Fire-proof door	When the fire door is under linkage control, the fire door cannot be closed automatically and the action signal cannot be fed back to the fire control device. Normally open fire doors are not equipped with sequencers

Table 11: The conclusion of summarized findings.

Items	Whether it supports the hypotheses	Findings
1	Yes Yes Yes	(1) The initial installation does not meet the requirements (2) The equipment is damaged, the maintenance is not in place, and some alarm functions cannot function normally (3) The products have not been tested, the responsibilities of management personnel are unclear, and the management is not in place
2	Yes Yes Yes	(1) There is a lack of technical measures for fire protection, and the equipment startup process is obsolete (2) The operation and maintenance personnel are derelict, fail to test and operate the equipment in time, and the cleaning and sanitation management is not in place, which affects the service life of the equipment (3) Manual management is negligent, and false alarms occur frequently when there is no management
3	Yes Yes	(1) The fire extinguishing system cannot flexibly respond to emergencies (2) The maintenance structure was not replaced in time
4	Yes Yes	(1) The monitoring and management on the evacuation exit are not in place (2) The fire-fighting facility system is not separated from other systems

because they were not carefully filled in. 50 offline questionnaires were eventually withdrawn, of which 4 were not carefully filled out and were not included in the scope of the study. Table 14 is the feedback on traditional fire-fighting, and Tables 15 and 16 are the feedbacks on artificial intelligence fire-fighting total of 91 valid questionnaires were used to summarize the final valid data for comparison.

From the first table, we can see that in Shenzhen Library, 90% of the interviewed employees think that they are not satisfied with the teaching and management training of fire-fighting facilities, 76% of the respondents are satisfied with the supervision and management of fire-fighting facilities, but only 10% of them are very satisfied. In terms of operation and maintenance management, 64% of the employees express a relatively satisfied attitude, and 32% of the respondents are still dissatisfied because the interviewee mentioned in the comment column that the fire hydrant is now in a damaged state.

From the second table, overall, the satisfaction of the artificial intelligence fire management system is significantly higher than that of the traditional facility management. There is a slight shortage in personnel management and training, and the satisfaction is lower than the other two aspects. To research the reason of this phenomenon, further investigation will be made after that.

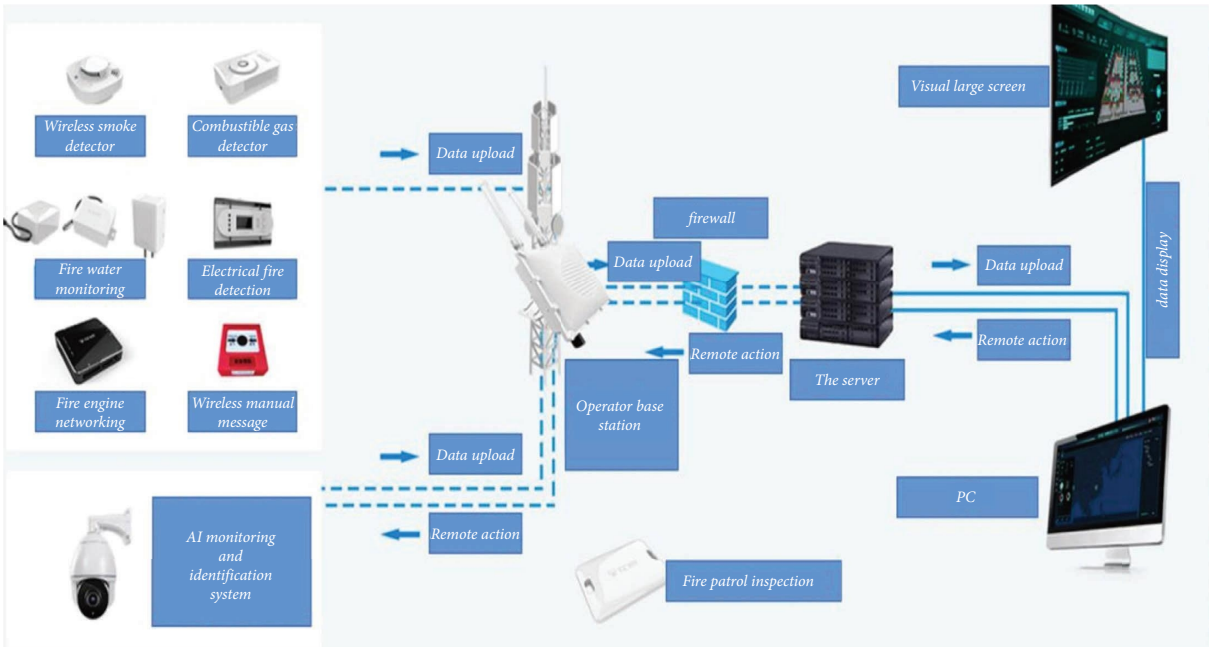

Figure 6: AI fire-fighting facilities management system. Source: Lian technology company.

Table 12: Interview feedback of the manager.

Functional items	Specific performance
Fire detector	In addition to the local deployment of smoke detectors, they can also be deployed. For example, for key areas in the museum, it can provide real-time monitoring of smoke, electrical, combustible gas, and other risk indicators and realize second speed alarm and remote notification at the first time when hazards are found, greatly reducing the emergency response time. According to the specific environment, intelligent smoke temperature integrated detector, gas detector, and power detector can be configured
Fire alarm controller	First, for the teaching building that has been installed with an automatic fire alarm system. The project has actually installed one vertical cabinet fire alarm controller and one piano-type fire alarm control and one Shanghai zero line electrical fire monitoring controller. We use user information transmission equipment to realize centralized cloud platform management of two independent systems. Among them, the printer parallel ports are used between the alarm controller and the user transmission device to collect data, while TCP and GPRS modes are used to upload to the cloud platform
Fire linkage control equipment	The intelligent smoke detector and intelligent video camera are linked to the intelligent fire cloud platform to conduct real-time dynamic monitoring in the museum, and the combustible gas detection device is installed to realize system linkage
Water supply system	The internet of things fire hydrant and the campus overall water source monitoring system are used to realize the "intelligent" management and maintenance of fire hydrants in the campus. Establish a "smart fire hydrant management system" for fire hydrants, and implement accurate positioning, water pressure monitoring, and damage alarm for campus fire hydrants through internet of things technology, so as to meet the needs of fire hydrant maintenance and fire-fighting operations in the library. At the same time, the intelligent fire hydrant management system is connected to the fire remote monitoring platform to realize the real-time display of the location of the fire hydrant, the water supply pressure, the remote on-site management of the mobile terminal, the monitoring of theft, water theft, damage, collision and other abnormal conditions, and the intelligent distribution of fire hydrants for fire fighting and rescue operations
Indicator	In the intelligent fire protection system, RFID technology is applied in combination with handheld inspection terminals to carry out information management of fixed fire equipment and facilities, which is combined with personnel management to form a closed-loop management and improve the efficiency of supervision, so that the daily inspection and maintenance of fire equipment and facilities can be effectively implemented

Table 12: Continued.

Functional items	Specific performance
Automatic fire alarm	The fire passage is blocked, and the corridor passage is blocked. Through the intelligent video surveillance camera, the fire passage will intelligently monitor all the fire passages in the area. Once the fire passage is blocked, the system will automatically push the running mobile app. At the same time, the alarm short message will be sent to the mobile phone of the relevant security personnel to remind them to deal with the occurrence process of the automatic storage event in time, clear the occupation and automatically reply to the alarm, and record the occupation time. If it is not cleared for a long time, send a warning message directly to the upper level of the property until it returns to normal. All operation processes can be directly viewed on the computer and mobile phone
Fire power supply	The installation and use of Nb IOT-based smart and safe electrical devices and electrical fire monitoring systems in densely populated places such as libraries will focus on solving the safety problems of fires caused by electrical equipment failures, improper power consumption, and other reasons. Conduct real-time monitoring, alarm, feedback, and recording of excessive residual current, short circuit, over temperature, and other electrical faults of the distribution system, establish intelligent electrical monitoring, fire alarm, and remote automatic power-off function system, and improve the power safety management ability of units and individuals and the hidden trouble handling ability of electrical safety

Table 13: Comparison of traditional and AI fire-fighting system.

Traditional fire-fighting facility	The initial installation does not meet the requirements The equipment is damaged, the maintenance is not in place, and some alarm functions cannot function normally The products have not been tested, the responsibilities of management personnel are unclear, and the management is not in place There is a lack of technical measures for fire protection, and the equipment startup process is obsolete The operation and maintenance personnel are derelict, fail to test and operate the equipment in time, and the cleaning and sanitation management is not in place, which affects the service life of the equipment Manual management is negligent, and false alarms occur frequently when there is no management The fire extinguishing system cannot flexibly respond to emergencies The maintenance structure was not replaced in time The monitoring and management on the evacuation exit are not in place The fire-fighting facility system is not separated from other systems
AI fire-fighting facility	The monitoring content is more extensive. In the past, the monitoring center only emphasized the monitoring of fire alarm information. The current system has expanded the monitoring of the water system and the behavior monitoring of inspectors and maintainers on the basis of the previous networking center. "Internet of things" and "internet of people" make monitoring data more valuable The innovative software application mode, in which the manufacturer uniformly deploys the application software on the server, customers can pay the manufacturer according to their actual needs, according to the number and duration of the ordered services and obtain the services provided by the manufacturer through the internet. This mode completely allows users to decide to invest in the maintenance and management of fire-fighting facilities Using this system, paper inspection cards and maintenance reports can be completely cancelled, and electronic inspection records and maintenance reports can also be effectively interactive. The big data generated by the maintenance reports between units makes it easier for managers to find inductive and early warning batch data. The system supports customization, can design spreadsheets according to needs, can carry out patrol inspection and maintenance management of professional fields and equipment such as fire protection, expand the scope of services, and improve the cost performance of products

From the third table, we can see that the managers are generally satisfied with the fire-fighting facilities management platform applied in the school library. Compared with different factors, the difference is small. The only thing worth noting is the column of learnability, in which 20% are not satisfied. We found these 10 respondents and conducted in-depth interviews with them. Their average age is more than 50 years old, and the oldest is 55 years old. According to the interview, Age and education level are also one of the factors restricting the management and promotion of intelligent fire-fighting facilities.

From all the statistical analyses carried out, we make the observation that in some cities in China, the application of artificial intelligence can improve the efficiency of fire facilities management, but it still takes time for extensive application and promotion. The results laid a foundation for statistical analysis of the scope and feasibility of specific links related to the investigated phenomena.

4.4. Findings and Discussions. In order to make the comparison of interview results clearer, we summarized the interview and questionnaire results of two typical cases.

Table 14: Questionnaire feedback of traditional fire-fighting facility.

No	Dependent variable questions	100%	80%	60%	40%	20%
1	Personnel management and training	1	1	15	19	10
2	Supervision of fire-fighting equipment	5	15	23	2	1
3	Operation and maintenance of fire-fighting equipment	3	10	19	8	4

Table 15: Questionnaire feedback of AI fire-fighting facility.

No	Dependent variable questions	100%	80%	60%	40%	20%
1	Personnel management and training	21	13	9	2	0
2	Supervision of fire-fighting equipment	25	16	2	1	1
3	Operation and maintenance of fire-fighting equipment	29	5	0	1	0

Table 16: Questionnaire feedback of intelligence platform.

Item	Dependent variable questions	100%	80%	60%	40%	20%
Accessibility	Page layout	34	10	1	0	0
	Intelligibility	38	2	3	2	0
	Learnability	25	10	2	6	2
	Operability	29	15	0	1	0
Functionality	Completeness	30	11	2	1	0
	Applicability	35	10	0	0	0
	Correctness	32	12	1	0	0
	Compliance	33	11	1	0	0

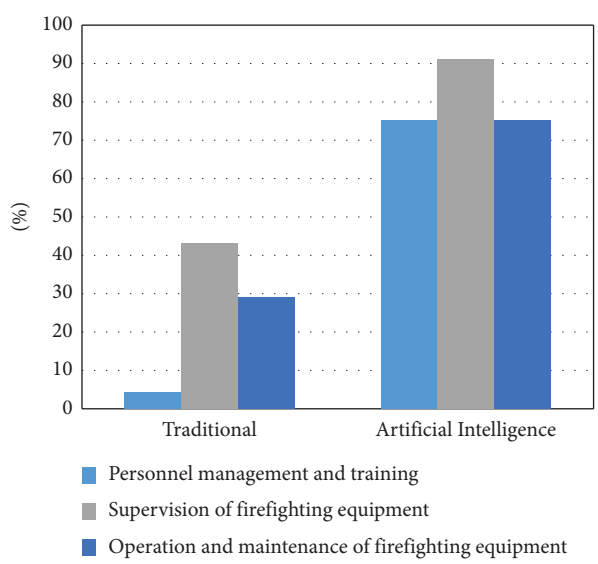

Figure 7: Data collected from the questionnaires.

Figure 7 is a bar chart comparing the satisfaction of the two groups of questionnaire respondents to the two fire-fighting facilities management systems.

Through the above-given research, we obtained the basic data of employees' satisfaction with artificial intelligence. In order to further explore the effectiveness of various applications of artificial intelligence in the management of fire facilities, we also conducted a more detailed questionnaire survey on the staff of Zhongbei university library. Combined with the shortage of intelligent management in personnel training in the basic data, and due to the time reason of the research, we only selected eight questions about the accessibility and functionality of the artificial intelligence platform for the satisfaction survey. For better longitudinal comparison, we draw the following histogram according to Table 16. It can be seen that most employees are 100% satisfied with the intelligent platform. It is worth noting that their satisfaction with Learnability and Operability is lower

Table 17: Conclusion of the findings.

Method	Data	Analysis	Conclusion
Interview (traditional)	There are 21 fire-fighting facilities with potential safety hazards. Accounting for 70% of the total survey facilities	The management of fire-fighting facilities is not in place. The damage rate of fire-fighting equipment is high, and the maintenance is not timely. The management personnel have the lowest satisfaction with staff training, and the satisfaction with equipment operation and maintenance and supervision is less than 50%	The traditional fire-fighting facilities management personnel are redundant, and the supervision and maintenance are not effective. In the long run, the safety and effectiveness of the equipment can not be guaranteed, and there are potential safety hazards in public buildings
Questionnaire (traditional)	The satisfaction of training, the supervision and O & M of fire-fighting is 4%, 43%, and 29%		
Interview (AI-technology)	The operation of artificial intelligence operation and maintenance system is in good condition, and there is a slight shortage in personnel training	The interview results show that the artificial intelligence platform reduces the personnel cost and improves the management efficiency of fire-fighting facilities. The survey results show that most employees are satisfied with the artificial intelligence platform, and the two results are consistent	Compared with traditional management methods, artificial intelligence fire-fighting facilities management is more effective
Questionnaire (AI-technology)	The satisfaction of training, the supervision and O & M of fire-fighting is 75%, 91%, and 75%		
Sub questionnaire (intelligence platform)	In the satisfaction ranking, intelligence is the highest, and ease of learning and operability are the lowest	It can be inferred that in the promotion and application of the intelligent platform, no attention was paid to the training of the quality of all employees, which led to the lack of operational proficiency of the management personnel on the platform and also affected the effectiveness of artificial intelligence in the management of fire facilities	It can be inferred that this is one of the reasons why employees are dissatisfied with the training of personnel in artificial intelligence management

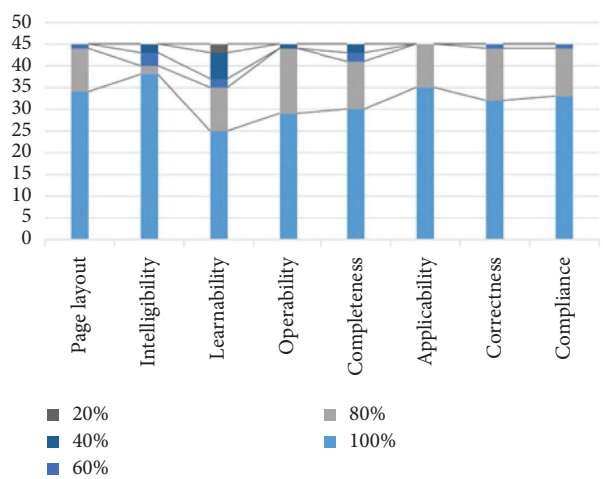

Figure 8: Data from the questionnaire of satisfaction feedback of the intelligence platform.

Table 18: Interview survey on traditional fire-fighting system.

No	Questions
1	Is the whole process control over the setting of building fire-fighting facilities carried out?
2	What are the design and construction units? Is the qualification qualified?
3	Are the auxiliary fire-fighting supporting facilities complete?
4	Which manufacturers do fire products cooperate with? Is the quality strictly controlled?
5	Whether the fire-fighting facilities are in normal and stable operation at all times?
6	Whether the management personnel of fire-fighting facilities regularly carry out education and training?
7	If there is education and training, how about staff participation? (good/OK/bad)
8	Whether new management concepts and methods are introduced in combination with the actual situation?
9	What suggestions do you have for your company's fire facility management system?

Table 19: Interview survey on existing intelligent fire-fighting system.

No	Questions
1	Do you know anything about intelligent fire fighting?
2	Does the company apply AI fire management system?
3	In which links of facility management has AI been applied?
4	What intelligent technologies are mainly applied?
5	Is the implementation in good condition? Proficiency rating of personnel application (10/50/90/100)
6	Is there any training on the application of new systems?
7	Is the management efficiency improved before and after the application of intelligent system? Is there still negligence?
8	What suggestions do you have for your company's fire facility management system?

Table 20: Questionnaire feedback of Traditional fire-fighting facility

No	Dependent variable questions	100%	80%	60%	40%	20%
1	Personnel management and training					
2	Supervision of fire-fighting equipment					
3	Operation and maintenance of fire-fighting equipment					

Table 21: Questionnaire feedback of AI fire-fighting facility

No	Dependent variable questions	100%	80%	60%	40%	20%
1	Personnel management and training					
2	Supervision of fire-fighting equipment					
3	Operation and maintenance of fire-fighting equipment					

Table 22: Questionnaire feedback of AI fire-fighting facility.

Item	Dependent variable questions	100%	80%	60%	40%	20%
Accessibility	Page layout Intelligibility Learnability Operability					
Functionality	Completeness Applicability Correctness Compliance					

than others. It can be inferred that this is one of the reasons why employees are dissatisfied with the training of personnel in artificial intelligence management.

The information reflected by the obtained data is summarized in Table 17. Summary and analysis have shown that the effectiveness of the artificial intelligence fire

protection facility management system is obviously higher than that of traditional facility management in practical application (Figure 8).

5. Conclusions and Recommendations

The purpose of this study is to illustrate the effectiveness of the application of artificial intelligence in the management of fire facilities. In the whole research process, the management of fire-fighting facilities includes the training and teaching of fire-fighting facilities supervision, fire-fighting facilities operation and maintenance, and fire-fighting facilities management, so as to see whether the management efficiency can be improved through the application of artificial intelligence technology.

The innovation of new technology is often based on the fact that traditional technology cannot meet the development needs of the material world. There are some defects in the management of traditional fire-fighting facilities through research, and these defects can be well solved by using new technical means. Through the research on the management of traditional fire-fighting facilities in Shenzhen Library, the interview materials with managers and the questionnaire survey results of staff are obtained. The survey results show that the management of traditional facilities is indeed difficult to meet the complex fire-fighting requirements of large-scale public buildings, and innovative technical means are needed.

AI has corresponding technologies to solve the problems in all aspects of fire facility management. First, in terms of supervision, compared with the traditional regular patrol of employees, intelligent cameras will capture various details and can monitor in multiple time and space. The automatic alarm system can quickly make alarm instructions after the intelligent cameras accurately identify risks. Secondly, in terms of operation and maintenance, AI big data technology can automatically collect uninterrupted operation and maintenance data, timely report equipment damage, and timely repair. However, in the teaching and operation link, artificial intelligence has not been applied to this link. Compared with traditional facility management, in the practical operation link, hand-in-hand teaching and practical operation make employees more satisfied. Artificial intelligence technology can improve the management efficiency of fire-fighting facilities in most links.

Artificial intelligence is a trend in the development of facility management in China through literature and field investigation and then infer that the application of artificial intelligence technology is effective for fire facility management. We found that the promotion of AI technology in China is very insufficient, but many scholars have made a research on this part of the theory. Zhang cited many practical examples of the application of AI in Construction Engineering [1], which is consistent with the research results of North China University. Compared with domestic, foreign research in this area is much ahead of schedule, and artificial intelligence has become an irresistible trend, so the development of fire facility management in the future needs to conform to this trend.

Taking Shenzhen Public Library as a typical case of the traditional facility management system, this project studies the defects of public buildings in developing cities in China in the management of fire-fighting facilities and finds that in the supervision, operation, and maintenance of fire-fighting facilities, due to the increasing complexity of buildings, the traditional manual management cannot comprehensively and efficiently deal with a large number of complex facility problems, resulting in poor equipment operation, untimely operation, and equipment damage The blockage of fire-fighting passages and other problems have brought huge hidden dangers to the fire safety of buildings.

Through the study of typical cases of artificial intelligence fire-fighting facility management system, it is concluded that the addition of artificial intelligence technologies such as intelligent supervision system, intelligent fire alarm system, intelligent operation, and maintenance platform, makes the management of building fire-fighting facilities reduce the labor cost, improve the efficiency of facility management, and meet the fire-fighting management needs of large public buildings.

At this stage, the management of fire-fighting facilities in developing cities in China is still in the traditional stage. The managers' awareness of intelligent operation and maintenance is not deep enough. The effectiveness of traditional fire-fighting facilities management methods lags behind that of artificial intelligence management methods. However, it should be noted that according to the survey data, we can find that although the employee satisfaction of the artificial intelligence platform is higher than that of the traditional management measures, there are still a few dissatisfied situations. Due to the time limit, this study did not conduct in-depth interviews with the dissatisfied people again, so the current artificial intelligence fire management platform still needs to be improved. In a word, this research will help to provide an empirical application of artificial intelligence and promote the transformation of the traditional facility management system to informatization, intelligence, and efficiency. Secondly, as the existing intelligent platform still has certain defects, it can spur emerging enterprises to further study and explore.

5.1. Limitation of the Study. This study has some shortcomings. In general, this study does not represent the facility management status of all companies in China, as data were collected only for employees in typical buildings in two cities in China. In addition, especially under the influence of the pandemic, it is a great challenge for those who can participate to complete the questionnaire. The ways to collect data in this study is the online and offline questionnaire and interview, due to time constraints, respondents are likely to be unable to answer the questionnaire honestly and thoughtfully.

5.2. Contribution of the Study. With the rapid development of China's economy, large-scale comprehensive complex buildings continue to emerge, and fire safety is facing great challenges. As the probability of fire increases and the

difficulty of fire prevention and control increases, the new situation is testing fire safety managers. Fire safety infrastructure can not adapt to the rapid development of the economy and society. Therefore, in order to meet the needs of modern fire management and building information management, the effectiveness of artificial intelligence applied to building fire protection facilities management is studied. By applying artificial intelligence to the management of fire-fighting facilities, we can timely and accurately grasp the relevant information of fire-fighting facilities, improve the management level, reduce the management cost, simplify the management mode, and improve the reliability of fire-fighting facilities, so as to achieve the information management of the whole life cycle of fire-fighting facilities. When a fire occurs, fire-fighting facilities can effectively play the role of fire-fighting, so as to reduce the loss caused by fire.

This project analyzes the shortcomings of the current management mode of fire-fighting facilities, which leads to the unclear information and status of fire-fighting facilities, and the poor integrity of fire-fighting facilities so that the fire-fighting function cannot be effectively played when a fire occurs. Based on the large variety and quantity of fire-fighting facilities in large and complex buildings, it is difficult to effectively manage the information of fire-fighting facilities, so an effective information-based management method is needed. On the basis of consulting a large number of relevant literature at home and abroad, this project puts forward the information management mode of building fire-fighting facilities based on artificial intelligence and analyzes the application of artificial intelligence in fire-fighting facilities management and fire-fighting management.

According to the summary of past research [35–37], it is found that artificial intelligence has been applied in construction engineering and fire rescue, but there is little research on artificial intelligence in the management of building fire-fighting facilities. Through the investigation of the current situation of fire-fighting facilities management and the summary of artificial intelligence technology, this study studies the effectiveness of artificial intelligence in the management of fire-fighting facilities, makes up for the research gap of artificial intelligence in the field of fire-fighting facilities management, and provide data and theoretical basis for subsequent related research.

In short, with the development of artificial intelligence technology, it is an inevitable trend to apply artificial intelligence to building fire management. I believe that the management mode of fire facilities in China will enter the information age, and the fire safety management will be more perfect.

5.2.1. Contribution to Industry. This research can help industry practitioners better understand the impact of these factors on the adoption of AI in developing cities in China. The industry can consider introducing artificial intelligence technology to improve the efficiency of fire management. Especially when solving different management defects, selecting targeted artificial intelligence management methods can reduce the cost of human management in the long-term development and improve the development level of the whole building fire management industry.

Appendix

A. Interview of Traditional Fire-Fighting facilities

The investigation on traditional fire-fighting facilities is conducted online (Table 18).

B. Interview of AI Fire-Fighting Facilities

The investigation on AI fire-fighting facilities is conducted online (Table 19).

C. Questionnaire of AI & Traditional Fire-Fighting facilities

(a) Part A

Respondents

Profile

Qualifications

A. Bachelors B. Masters C. PhD D. Others

Working experience

A. Less than 5 years B. 5–10 years C. more than 10 years

(b) Part B-Dependent Variable Questions. Please choose your satisfaction with the following aspects of facility management: 100% = strongly satisfied 80% = satisfied 60% = neutral 40% = unsatisfied 20 = strongly unsatisfied (Tables 20-22).

Data Availability

The data used to support the study are provided and supported by the National Bureau of Statistics.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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