Architectural Design of Large Terminal Building Based on Embedded Multifunctional Security Warning System

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Abstract. In recent years, with the rapid development of the global aviation industry, the safety problems of large terminal buildings have become increasingly prominent. In order to ensure the safe and smooth operation of the terminal building, based on the application concept of embedded multifunctional security early warning system, this study puts forward an innovative multifunctional security early warning system for large terminal buildings. The hardware structure includes main control module, sensor, camera, audio equipment, network module, power management module, control panel and storage device. The functional modules work in coordination to expand the coverage of monitoring equipment. In the software part, the ant colony algorithm is used to establish the embedded multi-functional security system database, calculate the migration probability caused by the movement of two query nodes, obtain the weight of query paths, and stop updating pheromones. The fuzzy subset of data is determined in the embedded multi-functional security system database, and its membership function is calculated to realize the multi-functional security early warning of large terminal buildings. The experiment takes the international terminal reconstructed from T1 terminal of an international airport as the experimental object, with the reconstructed area of 24000m^2 and the throughput of 880,000 passengers. The experimental results show that the average false alarm rate of this method is low, and the safety early warning effect of medium and large terminal buildings is good in practical application.

Keywords: Embedded; Multifunctional; Security early warning system; Architectural design of large terminal building

1 Introduction

As the key hub of air traffic and the main distribution center of passengers, the security of the terminal building has become a crucial consideration [1]. According to FAA data, the total number of airport security accidents in the United States in 2016 was 440, a slight increase from 436 in 2015. These accidents include runway incursion, aircraft loss, dangerous goods leakage, gun incidents and so on. In 2016, there were many terrorist attacks in the global aviation industry, including explosions at airports in Berlin, Germany and Barcelona, Spain, and suicide attacks at Sharm el-Sheikh

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airport in Egypt. These incidents highlighted the importance of airport security and emphasized the need to strengthen security measures. According to ICAO data, the number of deaths in global aviation accidents in 2016 was 45, an increase from 37 in 2015. These accidents include plane crashes, aircraft lost contact, aircraft landing in dangerous areas and so on. These incidents not only caused casualties, but also brought great economic and image risks to airlines and airports. In order to ensure the overall safety management of the terminal building, it is very important to design a multifunctional safety early warning system for the building[2]. Reference [3] puts forward the seismic safety evaluation of URM building based on incremental dynamic analysis. In this study, URM building adopts equivalent frame modeling program, develops user-defined shear hinge and bending hinge characteristics, and obtains the vulnerability curve of URM building from incremental dynamic analysis, in which the uncertainty of earthquake time history characteristics is explained by using a group of remote site vibrations. Reference [4] establishes safety capability and aviation decision-making skills to avoid greater mistakes. In the ultra-safe and high-risk aviation industry, pilots tend to make decisions based on their best knowledge of available resources in the inherently error-prone system. This paper expounds the security ability from the perspective of Pioneer Security-II, and tests that the program as a static tool cannot maintain security.

Embedded multifunctional security early warning system is a comprehensive security solution, including video surveillance, intrusion detection, fire alarm and emergency help. The system can efficiently interconnect with the infrastructure of the terminal building through various devices such as sensors, cameras and alarm devices, and monitor and identify potential security threats in real time. On the basis of the above research, a design method of large terminal building based on embedded multifunctional security early warning system is proposed. This method applies embedded multifunctional security early warning system in the design of large terminal building, which can provide unprecedented convenience and responsiveness for the safety management of terminal building.

2 Application of Embedded Multifunctional Security Warning System in Architectural Design of Large Terminal Building

2.1 Hardware design of security early warning system

The hardware of security early warning system can monitor the environment in real time and carry out corresponding early warning and alarm processing. The hardware of security early warning system can realize environmental monitoring, video monitoring, alarm notification, remote monitoring and control, power management and data storage and analysis through the cooperation of each module. Environmental monitoring: Sensors can monitor physical quantities such as temperature, humidity, light, smoke and gas in the environment, as well as people entering and leaving, etc. The system can obtain environmental data in real time and analyze it[5]. Video monitoring: The camera can monitor a specific area or panoramic view in real time and collect video data. Users can watch video streams, play back videos and analyze images through the control panel or remote control to improve security and provide evidence. Alarm notification: When abnormal conditions, such as excessive temperature, smoke or gas leakage, are detected, the system can automatically trigger an alarm and play an alarm sound through sound equipment[6]. Data storage and analysis: Storage devices are used to store system configuration information, alarm records, video data, etc., and can support local storage and cloud storage services. The specific functions of the hardware components of the security early warning system are shown in Table 1.

Table 1. Specific function table of each component equipment

Constituting equipment	Function
Main control module	Mainly responsible for the overall function control and data processing of the system
Sensor	One of the core parts of the security early warning system is used to detect various physical quantities in the environment
camera	Used for monitoring and recording video, supporting real-time video streaming and remote monitoring
Sound equipment	Used for playing alarm sound or two-way communication
Network module	It is used to communicate with external networks to realize remote monitoring and data transmission
Power management module	It is used to manage the power supply of the system, and can choose to use AC power supply or DC power supply as needed, and provide stable voltage, current and battery management functions
Control panel	Used for users to interact with the system
Storage device	Used to store system configuration information, alarm records and video data, etc

2.2 Software design of security early warning system

Because the database of embedded multifunctional security system contains many contents and is complicated, ant colony algorithm is used to build the database. Suppose that the ant colony starts to query the embedded multi-functional security system database at t, and every ant in the ant colony is looking for the optimal path of data, but in the process of searching for the optimal path, it will be affected by the pheromone concentration, and the migration probability generated by moving from the query node i to the query node j is expressed as:

$$K_{DF}\left(t\right)=\frac{D_{ij}\left(t\right)\times F_{ij}\left(t\right)}{\sum k\left(t\right)\times\lambda} \tag{1}$$

In formula (1), $D_{ij}\left(t\right)$ represents the pheromone left on the path from query node i to query node j at t moment; $F_{ij}\left(t\right)$ represents the trajectory expectation value of t

moving from query node i to query node j at the moment; $\sum k(t)$ indicates the relative importance of ant query data trajectory; λ indicates the relative importance of expected values.

According to formula (1), ants tend to fall into the local optimal solution when querying data. Therefore, in the above calculation process, dynamic weighting rules are introduced to calculate the weight of each query path, so as to avoid the calculation result falling into the local optimal solution. When $K_{DF}(t)>1$, stop updating pheromones, and the query data on the obtained path is the data in the established embedded multifunctional security system database.

Fuzzy identification theory is an important field of fuzzy logic application, which provides a method to deal with data uncertainty and ambiguity. In the context of video surveillance data, fuzzy recognition theory is used to identify and classify different data types. In fuzzy logic, a fuzzy set is an extension of a traditional set, which allows the membership degree of elements to the set to be any value between 0 (completely not belonging) and 1 (completely belonging). Membership function is used to determine the degree to which an element belongs to a fuzzy set. Suppose $M_1, M_2, \cdots, M_n$ is n fuzzy subsets on fuzzy field, and there is data S. When the data S satisfies the following formula, it can be determined that the data S belongs to the fuzzy subset M_n.

$$S = \max\left[S_{M_1}, S_{M_2}, \cdots, S_{M_n}\right] \times K_{DF}(t) \tag{2}$$

Coordinator refers to the person or organization responsible for monitoring and processing data from various monitoring devices. Their main responsibility is to manage and analyze the data collected by monitoring equipment, and compare and judge according to the preset early warning threshold. The coordinator collects and sorts out the data collected by each monitoring device, and calculates the membership function value of each data sample. Membership function value is usually used to indicate the similarity or membership between a data sample and a specific category. After defining fuzzy set and membership function, fuzzy rules are defined to complete data type recognition. When the membership function is used for fuzzy identification, the expression of membership function is as follows:

$$L_{sd} = H \times S \times F_H \times B_D \tag{3}$$

In formula (3), H represents the classification data to be identified; F_H represents sample type data; B_D represents the monitoring data to be clustered. The coordinator compares the calculated membership function value with the early warning threshold. If the membership function value of a data sample exceeds the set threshold in a certain range, the coordinator will determine that there is a problem with the monitoring parameters corresponding to the data. Once the coordinator confirms the problem data, they will send an early warning instruction to the operator who is responsible for controlling the early warning equipment. The early warning instruction can be sent to the control center through the communication equipment in the system or directly control the early warning equipment to give an alarm. According to different warning levels, the early warning equipment may give out sound warning, light flashing warning or send warning information to relevant personnel. At the same time, according to different warning levels, the coordinator will deal with it accordingly. When there is a low-level warning, drive away people in the restricted area or take some simple safety measures. In case of high-level warning, emergency evacuation or other severe safety measures should be taken immediately to ensure the safety of passengers and airport personnel. So far, the research on the architectural design method of large terminal building based on the application of embedded multifunctional security early warning system has been completed.

3 Experimental analysis

In order to verify the effectiveness of the architectural design method of large terminal building based on embedded multifunctional security early warning system, experiments were carried out. The experiment takes the international terminal reconstructed from the T1 terminal of an international airport as the experimental object. The short-term target year of the terminal is 2030, and the passenger throughput of the international year is 880,000 passengers, mainly for the reconstruction of the current T1 terminal to meet the use of international flights at the airport, and meet the current requirements of large airports, countries, places and industries. The reconstruction area is 24000m^2, and the total investment of the project is 405 million yuan. The specific structure is shown in Figure 1.

Fig. 1. Overall structure diagram of experimental object

In order to make the experiment concise, the method in this paper is set as the experimental group, and the method in reference [3] and the method in reference [4] are set as the control group, and a comparative experiment is set. An embedded multifunctional security early warning system was installed in a large terminal building, and the building security experiment was carried out. Obtain the false alarm rate data in the security range of 1000m2-2000m2 as experimental data. The experimental results of the comparison of the false alarm rate data of this method, the method of reference [3] and the method of reference [4] are shown in Table 2.

Table 2. Comparative experimental results of false alarm rate data

Security scope/m^2	False alarm rate/% The method in this paper	Reference [3] method	Reference [4] method
1000	0.14	7.42	9.04
1200	1.25	8.12	9.65
1400	2.37	9.24	10.07
1600	3.45	9.78	11.25
1800	3.64	10.16	11.76
2000	3.85	11.08	12.37
Average value	2.45	9.30	10.69

According to Table 2, as the security scope increases, more data and events need to be processed, which leads to more false alarms in the system. When the security scope increases, the false alarm rate also increases. Compared with the methods in reference [3] and reference [4], the average false alarm rate of this method is the lowest in the security range of 1000m2-2000m2, which shows that this method has advantages in reducing the false alarm rate.

Compare the security warning effect of this method before and after application in the same time period, and take it as the key index to evaluate the effect of this design method in practical application. The result is shown in Figure 2.

According to Figure 2, before the application of this method, the security early warning effect of large terminal buildings was poor; After the application of this method, the security early warning effect of large terminal buildings is getting better gradually. It can be proved that the method in this paper has a good effect in practical application and has played a positive role in improving the safety of large terminal buildings.

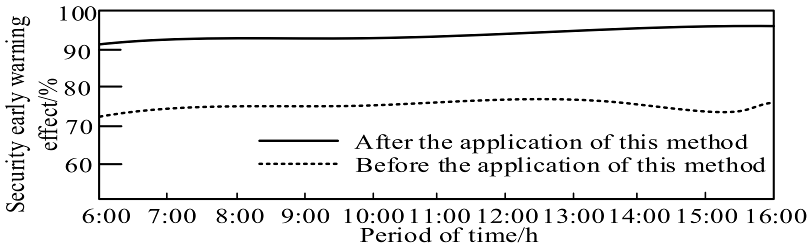

Fig. 2. Comparison of security early warning effects of large terminal buildings before and after the application of this method

4 Conclusion

This paper puts forward the architectural design of large terminal building based on embedded multifunctional security early warning system, aiming at ensuring the safe and stable operation of the terminal building. Based on the application concept of embedded multifunctional security early warning system, the system expands the coverage of monitoring equipment through the cooperative work of various functional modules. The database of embedded multifunctional security system is established by using ant colony algorithm, and the migration probability caused by the movement of two query nodes is calculated, and the weight of query paths is obtained, and the pheromone is stopped. The fuzzy subset of data is determined in the embedded multi-functional security system database, and its membership function is calculated, so as to realize the multi-functional security early warning of large terminal buildings. Taking the international terminal reconstructed from T1 terminal of an international airport as the experimental object, the results show that the average false alarm rate of this method is low, and the safety early warning effect of the method is good in practical application. This shows that the proposed method has important practical significance and application value in the field of terminal security.

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