Research on Intelligent Control Method of Fire Emergency Lighting Distribution in High Rise Buildings

Yi Zhong
School of Guangxi Polytechnic Of Construction, Nanning, Guangxi, 530007, China
E-mail: dongyongni@gilvertex.com

Abstract. Aiming at the problem of high energy consumption in the traditional intelligent control method of fire emergency lighting distribution in high-rise buildings, the intelligent control method of fire emergency lighting distribution in high-rise buildings is proposed. By using the data processing model of fire emergency lighting light environment of high-rise buildings, the data of fire emergency lighting light environment of high-rise buildings are normalized. By calculating the distance between lights and using the optimal mathematical model, the intelligent control algorithm of fire emergency lighting power distribution of high-rise buildings is designed. Finally, through the development of high-rise building fire emergency lighting power distribution intelligent control scheme, to achieve high-rise building fire emergency lighting power distribution intelligent control. Dialux is used to simulate the lighting system with dimming control. The simulation results show that the minimum illumination, total illumination uniformity and longitudinal illumination uniformity of fire emergency passage of high-rise buildings meet the lighting requirements under different walking speed and traffic flow conditions.

1. Introduction
Before the research on intelligent control of fire emergency lighting distribution in high-rise buildings, the relationship between intelligent control technology of fire emergency lighting distribution in high-rise buildings and intelligent control of artificial lighting should be made clear [1]. With the continuous development of intelligent technology, intellectualization penetrates into all fields of the national economy at an amazing speed. Among them, the intelligent control technology of fire emergency lighting power distribution in high-rise buildings has also been developed rapidly. At present, the types of related products and technical means are diverse, and the technology has begun to develop in the direction of popularization [2].

Intelligent control of high-rise building fire emergency lighting distribution is to use intelligent control technology to flexibly and reasonably control artificial lighting, and its purpose is to create a high-quality artificial lighting light environment, that is to say, intelligent control technology and artificial lighting of high-rise building fire emergency lighting distribution are two important components of artificial lighting intelligent control [3]. Reviewing the continuous development process of intelligent control in the field of high-rise building fire emergency lighting power distribution, we will find that the current artificial lighting intelligent control only stays in the conceptual stage of high-rise building fire emergency lighting power distribution intelligent control technology, and the research on how to use intelligent means to reasonably and effectively control high-rise building fire emergency lighting power distribution is almost blank. No wonder a considerable number of products in the market do not conform to people's behavior habits in terms of use performance, and do not meet
the control requirements of high-rise building fire emergency lighting power distribution. In fact, the purpose is to improve the quality of high-rise building fire emergency lighting distribution through intelligent control, and the intelligent control technology of high-rise building fire emergency lighting distribution is only a means to achieve this purpose.

Song Shizhan et al. proposed a voltage control method considering street lamp charging pile to solve the problem of voltage overrun in urban distribution network. Using high-efficiency light emitting diode (LED) street lamp to replace the transformer capacity released by traditional high-voltage sodium street lamp, an electric vehicle charging pile based on street lamp pile was constructed. Taking the electric vehicle charged and discharged by the street lamp charging pile as a controllable means to participate in the voltage control of the urban distribution network, the load characteristics of the electric vehicle charged and discharged by the street lamp charging pile are analyzed and modeled. Considering the working characteristics of the voltage regulating means in the distribution network, the multi-level voltage control strategy of the urban distribution network is proposed. Taking the minimum control cost of each voltage regulation measure as the objective function, the voltage regulation model is established, and the particle swarm optimization algorithm is used to solve the optimization model. According to the working characteristics of urban street lamp lighting load, the simulation analysis is carried out under two conditions of day and night. The simulation results show the effectiveness of using street lamp charging pile to participate in the voltage control of urban distribution network, and the control effect is better than the traditional voltage control method through comparative analysis.

Deng Jianzhi et al. studied a lighting control method of Karst Cave Scenic Area Based on visible light communication. The lighting control system was divided into lighting terminal and wireless controller, and the wireless control of lighting was realized by using visible light communication. The micro control system based on STM32F107 is used to encode and decode information and modulate visible light. The encoding and decoding method, data frame format, hardware design and software sending and receiving process of lighting control are given, and the system sending and receiving experiment of lighting control is carried out. The experiment proves the feasibility of the lighting control method. Using visible light communication technology to realize the wireless control of cave lighting can effectively overcome the shortcomings of radio wave communication, which has good research and application value.

Lighting distribution intelligent control system is a modern system which uses electromagnetic voltage regulation and electronic induction technology to realize real-time monitoring and tracking of power supply, and control power voltage and current amplitude, so as to optimize lighting efficiency and quality. Its platform is the corresponding unified system. At present, the intelligent control system of lighting distribution can be divided into two categories, one is line lighting control system, and the other is intelligent lighting control system. Compared with the traditional lighting control system, it can be found that the lighting distribution intelligent control system has many advantages. First of all, the lighting distribution intelligent control system can control and manage the lighting automatically, which can not only optimize people's daily work and living conditions, but also provide people with a comfortable lighting atmosphere. Secondly, the intelligent control system of lighting distribution realizes the optimal allocation of power resources, which has the advantages of energy saving and environmental protection. Finally, the lighting distribution intelligent control system has a protective function on the lamp, and can effectively extend the service life of lamps and lanterns.

2. Design of intelligent control method for power distribution of fire emergency lighting in high rise buildings

2.1. Preprocessing light environment data of fire emergency lighting for high rise buildings
After determining the type of light environment sensor, the light sensor, infrared sensor and image sensor are taken as the three eigenvalues of the system to denoise and filter the light environment data of fire emergency lighting in high-rise buildings. Because the sensor is heterogeneous information
type, and the data has different properties of indicators, it needs to be processed before the data fusion, because its evaluation has more generality, the data is normalized, and the formula is as follows:

\[
X_n = \frac{x_n - x_{\text{min}}}{x_{\text{max}} - x_{\text{min}}} \quad (1)
\]

\[
Y_n = \frac{y_n - y_{\text{min}}}{y_{\text{max}} - y_{\text{min}}} \quad (2)
\]

In the formula, \(x_n\) is the initial input value, \(x_{\text{min}}\) is the minimum value of the initial input, \(x_{\text{max}}\) is the maximum of the initial input values, \(X_n\) is the input value of the normalized neural network. \(y_n\) is the initial goal, \(y_{\text{min}}\) represents the minimum of the initial target values, \(y_{\text{max}}\) represents the maximum of the initial target values, \(Y_n\) represents the target value of the normalized neural network.

2.2. Design of intelligent control algorithm for fire emergency lighting distribution in high-rise buildings

Before determining the best lighting scheme, the determination of the input value in the algorithm implementation should be discussed. The current illuminance value of point a is sensed by the illuminance sensor deployed in the high-rise building. When all the lights are turned off, the illuminance sensor can obtain the current illuminance value of each sensor area in the high-rise building. After the sensor obtains the illuminance value, it sends the illuminance value to the server through ZigBee network, and the server saves the illuminance value to the database.

The luminous flux \(\phi\) of the LED lamp can also be obtained by the illuminance sensor, but since it is not necessary to know the specific value of the luminous flux of the LED lamp, it is only necessary to obtain the illuminance value of point A of the LED lamp under the full power working state by the illuminance sensor. Because the luminous flux \(\phi\) and \(4\pi\) in the sum \(\sum_{i=0}^{n} \frac{\phi \eta_i}{4\pi L_i}\) of the contrast value of the constraint condition are constant, that is, \(\frac{\phi}{4\pi}\) can be replaced by constant brightness \(K\), and the lighting control decision-making system only needs to decide the illuminance value of point A.

The distance between the \(i\)th lamp and point A can be calculated by 3D coordinates, and the specific 3D coordinates of each LED lamp can be stored in the database. When the coordinate of point A is determined, the distance between point A and each lamp can be obtained by formula (3).

\[
L_i = \sqrt{(x_i - x_a)^2 + (y_i - y_a)^2 + (z_i - z_a)^2} \quad (3)
\]

Based on the above discussion, the flow of intelligent control algorithm for fire emergency lighting distribution in high-rise buildings includes three steps. The first step is to determine the constraint conditions: determine the coordinates of the specific area to be illuminated, the number of lights \(N\) in the room, the specific coordinates of each light and the constant value of \(\frac{\phi}{4\pi}\); Then, by using the optimal mathematical model, the most energy-saving scheme to meet the lighting demand is calculated out of all available lamps; finally, the upper computer transmits the scheme to each lamp to control the illumination of the lamp in the high-rise building.

2.3. Develop intelligent control scheme of fire emergency lighting distribution for high-rise buildings

Stepless dimming control mode is adopted to adjust the output power of lamps according to the measured minimum illumination value of high-rise buildings, so that the illumination in high-rise buildings can always meet the lighting demand. In order to ensure the safety and comfort of the fire emergency passage of high-rise buildings, when adjusting the brightness of LED lights, the control
system adopts the control mode of gradual brightness change to achieve the target brightness step by step, so as to avoid the unsafe influence caused by the instantaneous change of brightness.

As long as the pedestrian flow is in any of the 3 value ranges, the control of lamp power only depends on the walking speed of people; this paper adopts the method of counting the pedestrian flow and walking speed every 20s to reduce the influence of the variation of pedestrian flow and walking speed.

3. Example analysis
Table 1 lists the single lamp power for dimming control of fire emergency lighting distribution system of high-rise buildings under different walking speed and traffic flow.

| Human walking speed / (m/s) | Visitors flowrate / (veh/h) | N ≥ 1200 | 350 < N < 1200 | N ≤ 350 |
|----------------------------|-----------------------------|----------|-----------------|--------|
| 80                         | 66                          | 47       | 28              |
| 70                         | 59                          | 40       | 24              |
| 60                         | 49                          | 29       | 20              |
| 50                         | 35                          | 24       | 20              |
| 40                         | 20                          | 20       | 20              |

It can be seen from Table 1 that when the lamp layout parameters are optimized according to the walking speed and traffic volume of the design personnel, without dimming control and without considering the light decay of the lamps, the lamp power meeting the illumination demand of the fire emergency channel of high-rise buildings is far less than the optimized power of 107W, which indicates that the lighting system with optimized lamp layout parameters still has huge energy saving space.

Figure 1 shows the total power of the lighting system of the intelligent control method for fire emergency lighting distribution of high-rise buildings, the total power of the system after the optimization of lamp distribution parameters and the total power of the system after the actual transformation with the walking speed and the flow of people.

Figure 1 Total power curve of lighting system

It can be seen from Figure 1 that the actual scheme after transformation and the scheme after optimization of lamp layout parameters are all lamp layout or optimization according to the designed walking speed and flow of people. No matter how the walking speed and flow of people change, the total power consumed is always 27.68kw and 16.692kw. Based on the optimization of lamp layout parameters, the dimming control of the lighting system is carried out, and the output power of the LED lamp is automatically adjusted according to the changes of walking speed and traffic flow. When the walking speed is 80m/s, the passenger flow is n ≥ 1 200veh/h, 350veh/h < n < 1 200veh/h and N
≤ 350veh/h, compared with the actual transformation of the electromagnetic induction lamp scheme, the energy saving can be more than 63.1%, 73.6% and 84.2%; compared with the optimization scheme of lamp layout parameters, the energy saving can be more than 38.8%, 56.3% and 73.8%. The optimized energy-saving control system can save energy significantly.

The lighting system after the optimization of lamp layout parameters is stepless dimming control, and the minimum illumination of fire emergency channel of high-rise building, the total uniformity of illumination of fire emergency channel of high-rise building and the longitudinal uniformity of illumination of fire emergency channel of high-rise building all meet the lighting requirements. The minimum illuminance of fire emergency passage of high-rise building is very close to the specified value of highway tunnel lighting design rules, and the error is very small, all within 3%.

4. Conclusion
In this paper, the intelligent control method of high-rise building fire emergency lighting power distribution is proposed. Based on the preprocessing of high-rise building fire emergency lighting light environment data, the intelligent control algorithm of high-rise building fire emergency lighting power distribution is designed. Through the development of high-rise building fire emergency lighting power distribution intelligent control scheme, the intelligent control of high-rise building fire emergency lighting power distribution is realized. Dialux software is used to simulate the lighting system with energy-saving control. The simulation results show that the minimum illumination, the total uniformity of illumination and the longitudinal uniformity of illumination in the fire emergency channel of high-rise buildings meet the lighting requirements, which proves the correctness of the energy-saving control system.

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