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APPLICATION OF INTELLIGENT LIGHTING CONTROL SYSTEM IN DIFFERENT SPORTS EVENTS IN SPORTS VENUES

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ABSTRACT

This paper analyzes the application of intelligent lighting control system in different sports events in sports venues, which is based on the perspective of computer technology. Firstly, this paper analyzes the characteristics of different sports events lighting system in stadiums, proposes a lighting demand analysis algorithm based on gray-scale modulation model, and designs a control algorithm based on neural network for intelligent lighting control system. Finally, the paper tests the designed algorithm and the results show that the intelligent lighting control system is effective. The application can play an important role in the optimization of lighting systems in different sports venues, with the value of further promotion in practice.

Keywords: intelligent lighting, control system, stadium, sports events, application

1. INTRODUCTION

With the continuous development of intelligent building technology, more and more intelligent systems were applied to various buildings. The intelligent sports system has also been widely used in sports venues as a place for sports events and sports activities. As an important part of the intelligent stadium system, the intelligent lighting control system has the advantages of intelligent control, efficient management, integration, energy saving, and environmental protection. Therefore, it is widely used in different sports programs in sports venues [1]. With the increasing attention and participation of sports, large-scale comprehensive gymnasiums have emerged nationwide. Unlike the small gymnasiums in the past, modern large stadiums are more functional, intelligent and user-friendly [2]. The modern comprehensive gymnasium not only provides basic sports venues, but also conferences, cultural events, exhibitions were held, which greatly improves the comprehensive utilization rate and economic utility of the stadium. At the same time, it also provides a more comfortable and modern sports venue [3]. As an important embodiment of the function of the stadium, lighting is an important part of the design of the stadium. The lighting of the stadium has different design requirements depending on the occasion. Since the main function of the stadium is to hold various sports events, the lighting of the competition, that is, the lighting of the stadium is an important part of the lighting design. The requirements for intelligent lighting system control are different for different sports [4]. Therefore, the application of intelligent lighting control system in different sports events in sports venues are studied and analyzed.

2. STATE OF THE ART

Stadium lighting is not only one of the prerequisites for the successful holding of sports events, but also one of the prerequisites for other functions of the stadium. It mainly illuminates the stadium, also known as sports lighting; of course, sports lighting also includes venue maintenance lighting, emergency lighting, auditorium lighting, etc. [5]. Some scholars believe that the choice of different lamps, different light sources, and the most appropriate intelligent lighting control system can make the lighting evaluation indicators such as colour temperature, glare index, horizontal and vertical illumination, illumination uniformity, colour rendering and other parameters of the stadium meet the required standards [6]. Some scholars believe that the application of an intelligent lighting control system is the basic requirement of modern comprehensive sports stadiums. Due to the diversity of sports venues, venues cannot only host different sports events but also perform entertainment activities such as evening performances, so lighting needs to meet a variety of uses. In most cases, the venue will was divided into multiple sub-sites for simultaneous activities [7]. Therefore, according to the different needs of the site, the lighting is divided into various scene modes, and the control was realized by the intelligent lighting control system. In recent years, with the continuous development and mutual promotion of computer technology, automatic control technology, network communication technology, and microelectronic technology, the development of intelligent lighting control systems is also deepening [8]. According to different environments, users can use the intelligent lighting control system to set different requirements according to their actual conditions, collect environmental information through the automatic acquisition system, and form feedback signals through the system to achieve the best lighting control effect [9].

3. METHODOLOGY

3.1. Gray-Scale Modulation Model Algorithm Based On Different Projects of Stadiums

For different sports events in sports venues, the application requirements of intelligent lighting control systems are also different. The design of the lighting control system should was based on the characteristics of the different operating items. The intelligent lighting control system consists of three parts: input, output, and system unit. The input section converts external control signals into system signals, including a control panel, an LCD (Liquid Crystal Display) touch screen, a smart sensor, and remote control; the output section receives control signals on the bus to implement lighting control, including a dimming controller, a switch controller, and an output. The system was powered by system power, PC (Personal computer) interface and monitoring to control computers and other components. Most lighting systems use a bus structure and communicate according to certain protocols. The Distributed mode was usually used, all components were connected by bus, and communication between components was performed in a peer-to-peer manner. At present, intelligent lighting control systems of different manufacturers use their bus protocol products, such as DyNet bus. Outdoor venue lighting systems require high brightness. In direct sunlight, the audience needs to see the above. Similarly, it should have strong windproof, protective, anticorrosive and lightning protection capabilities. The size should was determined according to the size of the venue, the size of the space and the capacity of the audience. Also, the venue is brighter and has a larger field of view [10]. Therefore, according to the specifications of different sports items, the intelligent lighting system should be determined according to the actual situation. The conclusion is clear that if the LED display in the intelligent lighting system was taken as an example, the specific settings can was referred to Table 1.

Table 1. Determination of the Size of the Frame of the Stadium LED Display

Stadium audience capacity	LED display frame size
1,0000 seats or less	3000 mm (height) × 10000 mm (length)
2000~3000 seats	5000 mm (height) × 15000mm(length)
3000~4000 seats	7000(height) × 20000mm(length)
More than 8,000 seats	8000(height) × 25000mm(length)

The pixel count N_{LEF} of the intelligent lighting control system can be calculated from the width and height of the lighting equipment. It is:

$$N_{LEF} = N_w \times N_h. \tag{1}$$

Where N_w represents the width of the lighting equipment in the model and N_h represents the height of the lighting equipment in the model. The number of pixels of the intelligent lighting control system is calculated from the perspective of the driver chip. It can also be expressed as:

Table 2. Proportion of Brightness Loss Within the Reference Time

ΔN_{latch} / N_{latch}	1	2	3	4	5
32	3.03	5.88	8.57	11.11	13.51
64	1.54	3.03	4.48	5.88	5.88
96	1.03	2.04	3.03	4.00	7.25
128	0.78	1.54	2.29	3.03	4.95
192	0.52	1.03	1.54	2.04	3.76
256	0.39	0.77	1.16	1.54	1.91

$$N_{LEF} = N_{ic} \times N_{ch}. \tag{2}$$

Where N_{ic} represents the number of driver chips used for one channel of data, and N_{ch} represents the number of channels included in each driver chip. If the latch length is defined as N_{Iatch}, obviously:

$$N_{Iatch} = N_{ic} \times N_{ch}. \tag{3}$$

For the data link with a length of N_{Iatch}, the time required for the transfer is τ_{Iatch}.

$$\tau_{Iatch} = \frac{1}{f_{clk}} \times N_{Iatch}. \tag{4}$$

In actual engineering use, there will be some idle clocks in the gap between each two transfer operations. The shift gap is used for timing adjustment, denoted as ΔN_{Iatch}, and then the time τ_0 required to transfer data once is expressed as:

$$\tau_0 = \frac{1}{f_{clk}}(N_{Iatch} + \Delta N_{Iatch}). \tag{5}$$

τ_0 is defined as the reference time of the scan, also known as a time slice, which is an important parameter based on time slice gray modulation. As can be seen from the above data, the reference time is increasing with the increase of the shift length, when the scan clock is constant. If the reference time is kept constant, the scan clock needs to increase as the shift length increases. The latch signal is a very narrow level signal, and the number of scan clocks is recorded as NLE, which is part of ΔN_{Iatch}. During the benchmark time, the bandwidth utilization and bandwidth loss rates are:

$$\begin{cases} \eta_{BL} = \dfrac{N_{latch}}{N_{latch} + \Delta N_{latch}} \times 100\% \\ \eta_{\Delta BL} = \dfrac{N_{latch}}{N_{latch} + \Delta N_{latch}} \times 100\% \end{cases}. \tag{6}$$

Table 2 shows the ratio of luminance loss in reference time. The first behaviour is the clearance of movement, which ranges from 1 to 5. The first column of the form is a shift length, with a length ranging from 32 to 256. The other part of the form is the luminance loss in reference time. The first column is the shifting length. The range is from 32 to 256. The other parts are the luminance loss during the reference time. It can be seen that when the transfer length is constant, the brightness loss in the reference time increases with the increase of the transfer gap; when the transfer gap is constant, the brightness loss decreases as the transfer length increases. In actual engineering applications, the transfer gap is generally set to be adjustable, in order to obtain better bandwidth utilization, if there is no special explanation about the calculation of the transfer gap mentioned later, taking $N_{Iatch} = 3$, if the transfer length is 256, the bandwidth loss rate is 1.16 % within the reference time. If the gradation level of the lighting equipment is *n* bit, the single primary colour image data is represented as *D* [(n-1): 0], and each bit of data is represented as *D* [n-1], *D* [n-2] … *D* [1], *D* [0]. During the reference time, the relationship between the stored serial data sequence *D*[x] and the data bits can be expressed as:

$$D[x] = \bigcup_{i=0}^{N_{LED}-1} D_i[x], (0 \le x < n). \tag{7}$$

From Equation 7, when x = 0, $D[0]$ ={$D_0[0]$, $D_1[0]$,..., $D_{N_{LED-1}}[0]$} it indicates serial data that is sequentially transferred in a time slice.

3.2. Design of Intelligent Lighting Control System for Different Sports Events in Stadiums Based on BP Neural Network Algorithm

The lighting control requirements of the stadiums are characterized by large venues, large number of circuits, a large number of lamps, scattered distribution of lighting distribution boxes, and usually need to achieve centralized control and locking. The comprehensive sports arena is not only used for formal sports competitions, but also for training, gatherings, exhibitions and other activities. Different areas and occasions have different requirements for lighting, and different lighting control schemes should be adopted according to different functions and occasions. It plays a key role in the overall environment, so in order to create a variety of lighting effects, changing the different spaces, the dimming and scene preset function need to be set. With the improvement of the intellectualization and integration of the stadium, it is necessary to integrate the stadium with other systems because of the higher and higher requirements for the linkage control and remote control of the lighting system. The overall design of the sports lighting system introduces a rotating light into the existing sports lighting system, and adds an input unit, a control panel, a wireless RF remote control, an output unit, and a luminaire rotary drive. The input unit and the output unit together form a luminaire rotation control system, which may also be referred to as a luminaire rotation controller. The unit is connected to the bus system via a standard communication interface. The introduced lamps and units can set the address code through software to establish the corresponding control relationship and realize the control function of the rotating lamps. The wireless remote control panel is mounted on the wall according to the site conditions, the wireless RF remote control is detachable and hand-held, and the rotary drive of the lamp is mounted in the rotating light.

BP network is a multi-layer forward network trained by error back propagation algorithm. This network consists of two processes: forward propagation of information and back propagation of error. The basic learning algorithm of BP neural network is called gradient steepest descent method. It is defined as adjusting the weight to minimize the total network error; that is, using gradient search technology to minimize the error mean square value of the actual output value of the network and the desired output value. The process of network learning can be seen as a process of correcting the weight coefficient while spreading. In the BP neural network structure, the three-layer network structure is composed of the input layer, the hidden layer and the output layer. There is no direct connection between the hidden layer (middle layer) and the outside world, but the neuron state of the hidden layer can influence and change the input and output. The idea of the algorithm is to continuously correct the network weight (ω_{ij}, T_{li}) and the enthalpy value (θ), so that the error can continue to decline along the direction of the negative gradient, and finally the satisfactory result can be obtained. The learning formula of BP neural network is as follows: where ω_{ij} is the network weight between the input node and the hidden layer node, T_{li} is the network weight between the hidden node and the output node, t_1 is the expected value of the input node, and t_1 is the input node and the output node is O_l. x_j is entered at the input node, the output of the intermediate node:

$$y_i = f\left(\sum \omega_{ij} x_j - \theta_i\right). \quad (8)$$

Output node:

$$O_l = f\left(\sum_i T_{ij} - \theta_l\right). \quad (9)$$

The connection weight is ω_{ij} and the node domain value is θ_l. For the output layer, the expected output of the output node is t_1, and then the error formula is:

$$\delta_1 = (t_1 - o_1)(1 - o_1)o_1. \quad (10)$$

Error control:

$$E = \sum_{k=1}^{p} e_k < \in. \quad (11)$$

$$e_k = \sum_{l=1}^{n}\left[t_1^{(k)} - o_1^{(k)}\right]. \quad (12)$$

Weight correction:

$$T_{li}(k+1) = T_{li}(k) + \eta\delta_1 y_i. \quad (13)$$

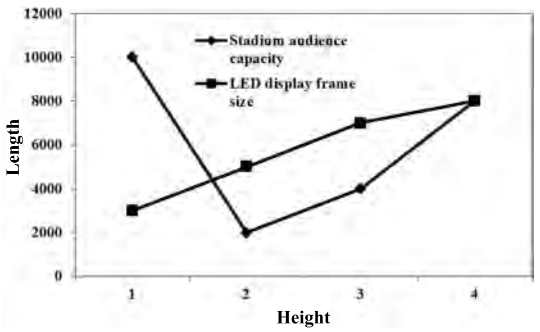

Fig.1. Determination of the size of the frame of the stadium LED display

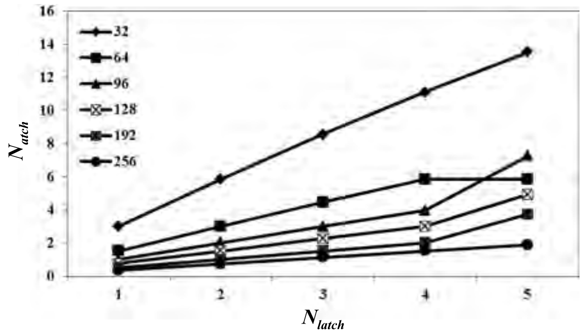

Fig.2. Proportion of brightness loss within the reference time

K is the number of iterations. For the devaluation correction:

$$\theta_l(k+1)=\theta_i(k)+\eta\delta_1 y_i. \quad (14)$$

4. RESULT ANALYSIS AND DISCUSSION

Based on the previous algorithm analysis, the application requirements of the illumination gradation display of the intelligent lighting control system in different sports events in the stadium are first analyzed. When the minimum pulse width is selected to be 40 ns and the refresh rate is 600 Hz, the relationship among the gray level, the shift length, and the scan clocks is as shown in Fig. 1, in which the scan clock is varied between 1 and 30 MHz. The storage length varies between 16 and 512, taking the LED intelligent lighting system as an example.

As can be seen from Fig. 1, its gray value varies between 14 and 15 bits, of which 14 bits are the most, 15 bits are less, are distributed in a few bands. The upper right picture shows the amplification of the low-speed clock area. It can be seen that when the transfer length is less than 200, the fluctuation of the gray level distribution fluctuates greatly. In the area above 200, the gray level changes relatively smoothly.

Fig.2 is a state in which the gradation level exhibits disordered fluctuations in the low-speed clock region where the transfer length is small. During the whole modulation period, the time slice matching algorithm realizes that the LED lighting control system illuminates according to a certain rule, so that the LED lighting fixture does not appear bright or off for a long time, thereby achieving the purpose of reducing the flickering of the display screen. According to the characteristics of LED lamp gray modulation, not only the evaluation strategy based on flash frequency factor is proposed, but also the qualitative evaluation of screen flicker is carried out. This method evaluates different time slice combinations and belongs to the category of gray modulation algorithms. The human eye produces a flickering effect on the rapidly changing light signal. Since the LED lighting fixture is intermittent, when the LED lighting fixture changes frequency is not fast enough, the human eye can perceive a noticeable flickering feeling. When the frequency of change is high, due to the visual inertia of the human eye, the observer will no longer feel flicker, the frequency that would normally not cause flicker, that is, the picture that the human eye can feel stable, is called the critical flicker frequency. The critical flicker frequency of the human eye is related to many factors: the brightness of the flickering picture: the higher the brightness, the higher the critical flicker frequency, the amplitude of the flicker: the larger the amplitude, the more obvious the flicker is perceived by the human eye. When the amplitude is less than the brightness that can be resolved by the human eye, the observer will not feel the flicker. Observation time, short-term observation is not obvious to the flicker, and it is easier to feel the flicker when observed for a long time.

Fig. 3 reflects the subjective evaluation of the display effect of the display screens of different

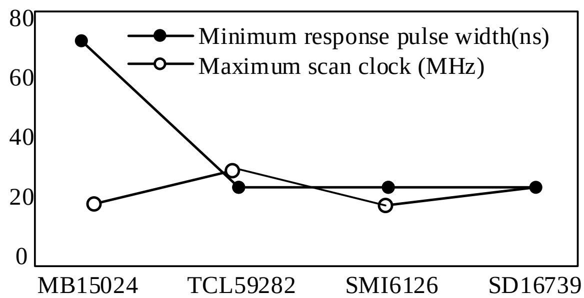

Fig.3. Little driver chip parameters

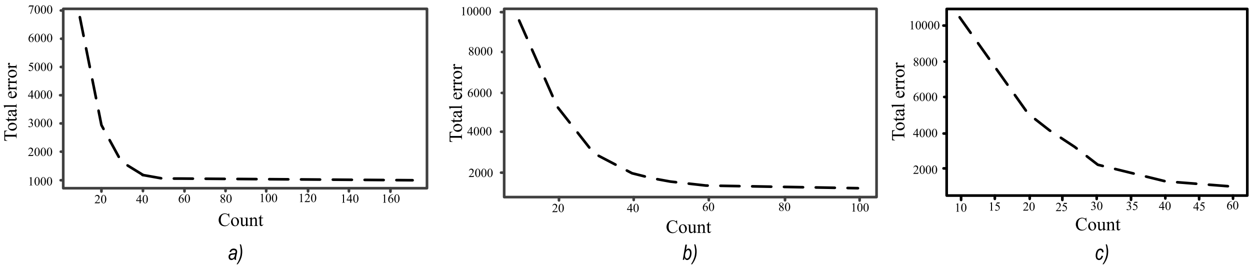

Fig.4. The BP neural network algorithm

Table 3. Classroom Lighting Monitoring Data

Input quantity		Output	
Standard of illumination (lx)	Luminaire power (W)	*X* axis coordinates (cm)	*Y* axis coordinates (cm)
150	39	169	214
	52	131	177
	18	99	149
	14	89	79
200	33	188	159
	35	98	189
	22	68	141
	51	79	71
300	61	120	117
	44	111	139
	37	89	201
	24	56	91

types of lighting control systems under different conditions. The observation results show that when the outdoor display brightness is greater than 4000 cd/m^2, it is better to use a refresh rate above 400 Hz; when the brightness is less than 4000 cd/m^2, it is better to use a refresh rate above 240 Hz. The degree of flicker is not enough to measure by the refresh rate, because in the case of the same refresh rate. The gray scale modulation algorithm is different, and the results are different. Therefore, for different sports in the stadium, the design of the display in the intelligent lighting system of each sports venue should be designed and applied according to the characteristics of the sports itself.

In order to design the most energy-saving luminaire installation scheme under the premise of meeting the illuminance standard value, the simulation experiment can be carried out through BP neural network. Generally, in different environments, the installation position and power of the luminaire have certain influence on the lighting effect. The model can be established by BP neural network, and the illuminance standard and the luminaire power are defined as the input quantity, and the installation position of the luminaire is defined as the output quantity, and they are trained. The experiment selects a classroom in the teaching building as the experimental object, and normalizes the input data of the BP algorithm to determine the input and output parameters of the network. The selection and determination of the parameters are selected according to the actual situation. The distribution and measured data of the lamps in the classroom are shown in Table 3.

The data used in the test indicates that the input is the illumination brightness and the lamp power. The output is the minimum horizontal and vertical spacing (in cm) of the fixtures installed in a given classroom. The default size of the schoolroom is 12m × 9m, for classrooms of different sizes; they can be tested by modifying the data. The fluorescent lamp is used as the test luminaire in the experiment. Since the 16W LED tube selected in this design is the same as the 40 W fluorescent lamp, the simulation result of the 40 W luminaire under test was used as the basis for the installation position of the luminaire in the design. The total error of the training obtained by running multiple times was shown in Figs. 4 (a), (b), and (c), and the error of the algorithm is graphically displayed, and is displayed every ten iterations.

Then the test results are obtained, it can was calculated through the test results that, to meet the illumination requirements, if a 40 W luminaire was used, in the 12m×9m classroom, 5 luminaires can be installed in the X-axis range, 6 luminaires can was installed in the Y-axis range, and 30 luminaires need to was installed in the entire classroom.

5. CONCLUSION

With the development of the stadium intelligent, the function of the clever lighting control system will be perfect. The wise lighting control system not only satisfies the complex lighting control requirements of the stadium but also chiefly reduces the maintenance management workload and improves the management level, which is unmatched by traditional lighting methods. Therefore, the intelligent lighting control system will become an indispensable part of the intelligent stadium system and has a very wide application prospect. A smart lighting control system suitable for modern stadiums was introduced. In the overall design of the system, according to the gray-scale modulation model, the gray-scale modulation is divided into central gray-scale modulation and extended gray-scale modulation, the optimal scanning clock selection method was given. The design algorithm of an intelligent lighting control system based on neural network is designed, with the conceived algorithm tested. The test results show that the design of this paper can play a perfect role in optimizing the lighting system of different sports events in the stadium.

REFERENCES

1. Cxue Z., Xu J. Application of Intelligent Lighting Control System in EMU. Technological Development of Enterprise, 2016, V28, #10, pp.100–108.

2. Yang K. Design of Intelligent Lighting Control System in Office Building. Modern Architecture Electric, 2018, V8, #2, pp.64–70.

3. Wang X. Discussion on intelligent lighting control system of the gym. Shanxi Architecture, 2016, V12, #2, pp.89–112.

4. Cong X U., Wang Y., Kang J. Application of Acrel-Bus Intelligent Lighting Control System. Modern Architecture Electric, 2017, V10, #4, pp.879–917.

5. Zhang J., Liu J. Application of CPLD in intelligent sensing lighting control system. Modern Electronics Technique, 2016, V25, #1, pp.75–93.

6. Yu-Ning Q U., Chang Q., Yu G E. Application of fuzzy PID control in intelligent street light control system. Chinese Journal of Power Sources, 2018, V60, #1, pp.81–94.

7. Fang G. Application of Intelligent Lighting System Control Technology in Shenzhen Ping An IFC. Building Electricity, 2016, V2, #2, pp.47–53.

8. Zhang W., Thurow K., Stoll R. A Context-Aware mHealth System for Online Physiological Monitoring in Remote Healthcare. International Journal of Computers Communications & Control, 2016, V11, #1, pp.142–156.

9. Weiping Zhang., Akbar Maleki., Marc A. Rosen., Jingqing Liu. Optimization with a simulated annealing algorithm of a hybrid system for renewable energy including battery and hydrogen storage, Energy, 2018, V163, pp. 191–207.

10. Barrios-Gomez, J. A., Maximiliano-Mendez, G., Cavazos-Gonzalez, A. Application of neuro-diffuse grey models with hybrid learning for prediction of temperature in hot rolling. DYNA, 2016, V91, #1, pp.16–17.

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