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Improvement of Light Environment Control Technology in Smart Classroom

Chuandong Bai, Rui Guo
School of Architecture and Arts, North China University of Technology, Beijing, 100144, China

Abstract: Classroom is the main place for students to study in class. The light environment in classroom not only affects students' eye health, but also affects their learning efficiency. As a kind of green energy, natural light plays an important role in improving the classroom light environment. In order to create a healthy light environment, a joint control model of natural light and artificial lighting is proposed by combining matrix analysis with control strategy. The classroom space is simulated by diallux software to demonstrate the effectiveness of the model. It is proved that the proposed joint control model can control the illumination in the classroom and create a comfortable and healthy light environment in the classroom.

Keywords: Smart classroom; Light environment; Environmental control

1. Introduction

Light is the necessary condition for human survival, which is the dependence on light, which makes people pay more and more attention to the research of light environment. The effects of light environment on human include short-term effect and long-term effect. Short term effect refers to the influence of light radiation within 8 hours, such as photochemical ultraviolet damage of eyes and skin [1]. Long term effect mainly includes flicker, glare and non visual physiological rhythm. Based on the influence of light environment on students' learning efficiency and health, the advantages and disadvantages of natural lighting are analyzed and the conclusion is drawn. Compared with artificial light source, the light environment constructed by natural light is more favorable for human health [2]. Because the natural lighting is difficult to meet the requirements of classroom illumination, this paper proposes a method to improve the light environment control technology of intelligent classroom.

2. Improvement Method of Light Environment Control Technology in Smart Classroom

2.1. Development status of classroom light environment control technology

In the long-term evolution of human beings, natural light is the main source of illumination. The advantages of natural lighting are mainly reflected in two aspects: indoor lighting with natural light is more conducive to the construction of healthy light environment. It has been found that under the same illumination level, people's visual efficacy in natural light environment is 5% - 20% higher than that in artificial lighting. Natural light is the dynamic change of light in nature, which can make the interior space produce rich expressive force and give people the feeling of openness, condensation, lightness and implicitness [3]. According to statistics, more than 30% of the classrooms in Colleges and universities use multimedia equipment for classes, 80% of the classrooms in urban primary and secondary schools have multimedia, and 50% in rural primary and secondary schools. As mentioned in the 13th five year plan of educational informatization in June 2016, the popularization rate of multimedia classrooms in Colleges and universities in China has exceeded 80%. According to statistics, the average length of study in primary and secondary school students is as high as 7-8 hours / day, and some even as long as 10 hours / day[4]. Therefore, multimedia classroom has become the main place for students to study and carry out various activities, and the quality of indoor light environment will directly affect students.

The application of multimedia technology in teaching is more and more extensive. At present, multimedia equipment has become an important part of the construction of teaching equipment in ordinary classrooms in Colleges and universities. In recent years, the use of multimedia classroom has brought a series of convenience to teaching work, and has also played a great role in promoting its development [5]. However, when students use multimedia classroom, the influence of indoor light environment on students' visual clarity, visual comfort and visual fatigue has not been fully concerned. Using natural light for indoor lighting is more conducive to energy conservation and emission reduction [6]. As far as lighting is concerned, natural light is a good green energy. Buildings with good natural lighting can make full use of natural light instead of artificial lighting, reduce the corresponding lighting energy consumption and alleviate the energy crisis. However, natural light is uncontrollable light. First of all, due to the existence of a certain ratio of window to wall in the building, it is difficult to evenly and effectively irradiate the whole indoor space; in addition, in cloudy days, the sunlight is weak and the indoor illumination is low, while in sunny days, the sunlight is strong and the indoor illumination is strong [7]. Therefore, the indoor illumination changes and uneven distribution in the classroom, which is not suitable for students' study and life. The main influence parameter indexes of multimedia classroom light environment are summarized, and the values of various parameters required by relevant national standards are counted, as shown in the table below.

Table 1. Numerical statistics of parameters required to be achieved by national standards

Number	Influence parameters	The scope of relevant regulations in China
1	Illumination	The reference surface illumination standard value is set as 300lz
2	Illumination uniformity	It should not be less than 0.6
3	Brightness	-
4	Brightness contrast	-
5	Color temperature	Appropriate use (3300-5300K)
6	Reflectivity	Roof 06-0.9; working face 0206
7	Glare	UGR of classroom should not be greater than 19
8	Stroboscopic effect	-

The above specifications are the requirements of the current national specifications. It can be seen from this table that the national specifications have made clear the standard requirements for parameters such as illuminance or illuminance uniformity, but have not specified the specific values related to brightness.

2.2. Intelligent classroom light environment control algorithm

Indoor illumination includes two parts: one is daylight illumination caused by natural lighting, the other is artificial illumination caused by artificial lighting. In this paper, through the establishment of classroom daylight lighting model and artificial lighting model, the joint control model of natural lighting and artificial lighting is obtained [8]. The parameters of a certain building, such as the area ratio of window to floor, the position of daylight opening, the total transmittance of window and the height of window edge are all determined values, so the natural lighting coefficient is only related to shading measures and indoor depth length. That is to say, in a certain depth of indoor, when the shading measures are adopted, the natural lighting coefficient is a function of the angle of the blinds. In this paper, the matrix of natural lighting coefficient function is introduced. Each element of the matrix is a function of natural lighting coefficient -- shutter angle function [9]. Different matrix elements represent the natural lighting coefficient function of different depths in the room. According to the concept of natural lighting coefficient, we can get the indoor daylight illuminance formula, where n is the room depth; Gn(w) is the natural lighting coefficient function at the depth of n; Ewd is the indoor daylight illuminance matrix.

$$E_{wd} = \begin{bmatrix} G_1(w) \\ G_2(w) \\ \vdots \\ G_n(w) \end{bmatrix} \times E_{wd} \qquad (1)$$

According to the theory of luminous transmission, the artificial illuminance matrix of indoor illuminance points can be obtained as shown in the formula. Where g is the luminous transfer function matrix, and the element gij of the luminous transfer function matrix is the light emission ratio (or luminous transfer function) of light source j to point i. When the position of the light source is fixed, the gij does not change and does not change with the output luminous flux of the light source.

$$\begin{bmatrix} E_{uc1} \\ E_{u2} \\ \vdots \\ E_{un} \end{bmatrix} = \begin{bmatrix} g_{11} & g_{12} & \cdots & g_{1m} \\ g_{21} & g_{22} & \cdots & g_{2m} \\ \vdots & \vdots & \cdots & \vdots \\ g_{n1} & g_{n2} & \cdots & g_{nm} \end{bmatrix} \times \begin{bmatrix} \varphi_1 \\ \varphi_2 \\ \vdots \\ \varphi_n \end{bmatrix} \qquad (2)$$

After the luminaire is installed in a space, its luminous flux transfer function matrix is determined to be invariable:

$$\varphi = \left(g^T g\right)^{-1} g^T E_{uc} \qquad (3)$$

The illuminance of a point on the working face in the classroom is composed of two parts, one is the daylight illumination caused by outdoor natural light, the other is the artificial illumination generated by indoor artificial lighting. The illumination formula of indoor illumination calculation point is as follows: E=Ew+Ewdsuch as formula (4).Where E is the illuminance matrix of the indoor reference point; En is the illuminance of the reference working point; Ew is the indoor artificial illuminance matrix; Ewd is the indoor daylight illuminance matrix; e day is the outdoor natural illuminance, which is measured by the outdoor illuminance sensor.

$$\begin{bmatrix} E_1 \\ E_2 \\ \vdots \\ E_n \end{bmatrix} = \begin{bmatrix} g_{11} & g_{12} & \cdots & g_{1m} \\ g_{21} & g_{22} & \cdots & g_{2m} \\ \vdots & \vdots & \cdots & \vdots \\ g_{n1} & g_{n2} & \cdots & g_{nm} \end{bmatrix} \times \begin{bmatrix} \varphi_1 \\ \varphi_2 \\ \vdots \\ \varphi_n \end{bmatrix} + \begin{bmatrix} G_1 & (w) \\ G_2 & (w) \\ \vdots & \\ G_n & (w) \end{bmatrix} \times E_{wd} \quad (4)$$

The control strategy of classroom joint lighting control system is to make full use of natural light to provide classroom lighting. By adjusting the angle of blinds to avoid direct sunlight and maximize the contribution of natural light to the classroom, reduce artificial lighting and achieve the purpose of energy saving [10]. When the optimal angle of the shutter is determined, the indoor daylight illuminance matrix is determined. Through the difference between the standard illuminance matrix and the Ew indoor daylight illuminance matrix, the Ew indoor artificial illuminance matrix can be obtained. According to the knowledge of matrix theory, the corresponding luminous flux output value of the light source can be obtained, and the on-demand supplementary lighting can be realized.

2.3. Optimization of light environment control equipment in smart classroom

In class mode, the blackboard light is turned on 500lx, the classroom lamp is on 300lx, and the curtain is opened in the daytime. The constant illumination sensor enters the working state, and the projector enters the standby state. In projection mode, the blackboard light is turned off, the classroom light is reduced to 150lx, and the curtain is closed [11]. The constant illumination sensor is in working state, and the projector is in working state. In the self-study mode, the blackboard light is off, the classroom light is 300lx, and the curtain is on / off. The constant illumination sensor is in working state, and the projector is in standby state. After class mode, the blackboard light is turned off and the color temperature is 2700k. The brightness of the classroom lamp is reduced to 40lx, the curtain is closed or opened, the constant illumination sensor is in the working state, and the projector is in standby mode [12]. Data visualization large screen light environment system monitoring data large screen, intuitive display of illuminance, air quality, carbon dioxide concentration, energy consumption, myopia rate of students and other parameters, reflecting the school information, intelligent. It not only serves as a window for parents to understand the school, but also provides real-time monitoring data and records for government departments, providing supervision and management convenience. The background management system of Internet of things can realize one key control of the status of all classroom equipment. Non contact strong current, avoid the traditional power house switch, avoid the impact of large current on the lighting appliances, and have a longer service life [13]. Real time monitoring of classroom equipment running status, automatic fault reporting, consumables reminder. Convenient energy-saving management, automatic timing switch. As the main body of classroom lighting, classroom lamp and blackboard lamp are all in the light environment management system of lierda Internet of things. In order to more intuitively select the acquisition method for indoor light environment test of multimedia classroom, the advantages and disadvantages of the two methods are compared and analyzed in the table below.

Table 2. Comparison of dynamic range image acquisition methods

	Image sensor capture method	Multiple exposure method
Image acquisition	At the same time exposure, direct acquisition, the system program is complex	Time sharing multiple exposure, the synthetic image is obtained indirectly
Scope of application	Both dynamic and static scenarios are applicable	Only for static scenes
Economy	Relatively expensive	Relatively cheap
Operability	Relatively complex	Relatively simple

By comparing the two image acquisition methods in terms of economy, applicability, convenience and operability, and considering the relatively stable and static light environment scene of the experimental object "College Multimedia Classroom", this study decided to use the time-sharing exposure image synthesis method which can provide enough information for the evaluation of the light environment to obtain the high dynamic range map Like [14]. The basic principle of software synthesis of high dynamic range image is to solve the inverse function of camera CRF function. The multi exposure image is fused to improve the dynamic range of the image, which can also effectively reduce the noise in each image. Using the above characteristics, we can obtain the required light environment information from the high dynamic range image. The relationship between the exposure (H) and the brightness (Eo) of the image is as follows:

$$H = E_0 \times t \quad (5)$$

Where t is the exposure time:

$$E_0 = \frac{\pi}{4 \times F^2} T \cdot B \quad (6)$$

Where T is the transmission coefficient of the lens, B is the actual brightness of the object, and F is the aperture of the camera.

$$H = B \times \frac{\pi}{4} \times \frac{T}{F^2} \times T \quad (7)$$

Through the above formula, the brightness of the measured object can be calculated. According to the above concept of brightness contrast, the method described above can not only extract the average value of brightness within the picture range, but also extract the brightness data of each required point according to the needs [15]. By comparing the values of the highest value and the lowest value of brightness, the brightness contrast value in the picture can be accurately extracted, so as to realize the effective light environment of intelligent teachers Research objectives of control.

3. Compare the Test Results

According to the data collection and investigation in the early stage of this study, the typical building plane selection of multimedia classroom in Colleges and universities is rectangular and side window lighting. Therefore, this experiment selects A100 "architectural optics laboratory" classroom of Tianjin University with common scale, rectangular plane, south facing unilateral side window lighting and adjustable lighting environment facilities Inspection site. Scene measurement was carried out in the laboratory to simulate the students' visual comfort and visual clarity in different light environments. In this study, the scene of students watching multimedia screen in the classroom is regarded as the indoor scene of the experiment, so the layout of the laboratory is arranged according to the actual multimedia classroom.

The actual indoor use space of the classroom is 8.2m in depth, 7m in width and 4.2m in net height (from the ground to the ceiling). There are two 3mx2.8m-high rectangular side windows on the south wall for day lighting. The contents of the projector are displayed on the west wall of the classroom on a 3.ox2.om white plastic projection screen. The test points are selected according to the lighting measurement method (GB / t5700-2008), the actual use space and visual identification materials of the classroom, the evaluation method required by the international visual evaluation table, and the actual use position of the relevant multimedia classroom seats. At the same time, combined with the size and position relationship of the projection screen, three different test points with horizontal distance of 3M, 5M and 7m from the projection screen are selected, and the vertical height of the measuring point from the ground is 1.2m (the specified sitting height in the lighting measurement method).

Dialux software is selected for simulation. The classroom model is a rectangle with a length of 9 meters and a width of 8 meters. The windows on both sides are shown in Figure 1. Setting the parameters, the reflection coefficient of the wall is 50%; the reflection coefficient of the floor is 63%; the reflection coefficient of the window is 10%, and the transmittance is 90%. The setting time is 10:00 a.m. on May 12, 2020, 113 degrees east longitude and 23 degrees north latitude. The gray scale isoillumination diagram is shown in the figure.

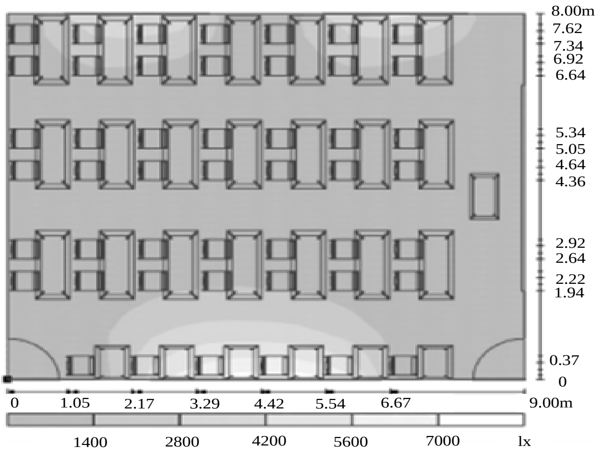

Figure 1. Experimental environment

The illuminance calculation points are measured every 0.5 meters from the blackboard 0.25 meters. Eight measuring points are evenly selected horizontally. When the outdoor illumination is 6000lx, according to the date, time, longitude, latitude and house orientation set by the model, with the help of artificial neural network, BP algorithm (reverse learning method) in the artificial neural network is used to predict the best shutter angle and obtain the maximum value of the shutter The optimal angle is 48 degrees. The EWD and the corresponding artificial supplementary illuminance matrix are obtained, and the light source output matrix is obtained. The power of 1, 2, 3, 7, 8, 11, 14 lamps are 54%, 25%, 59%, 46%, 33%, 25%, 68%, respectively. After the theoretical value is obtained, the effect is tested by Dialux software. When the outdoor illumination is 6000lx and the shutter angle is 48 °, the illuminance distribution in the classroom is as shown in the figure.

Figure 2. Light environment control effect of traditional method

Figure 3. Light environment control effect of this method

It can be seen from the figure that, compared with the traditional method, the light environment control effect of this method is obviously better than that of the traditional method. The calculation shows that after adopting the joint control strategy, the indoor average illumination is 541lx, the minimum illumination is 403lx, and the illumination uniformity reaches 0.74. Except for the illumination at the windows on both sides is about 1000lx, the other working faces are basically around 500lx, which meets the standard The control strategy has achieved good results. This paper introduces the research results of some existing classroom light environment, as well as the advantages and disadvantages of natural lighting. In view of the uneven illumination in the classroom, this paper puts forward the daylight model and artificial lighting model, and combines them to propose the joint control strategy. Finally, the joint control model is applied to the actual classroom model, and the simulation and effect analysis are carried out. It is concluded that the control strategy in this paper can make good use of natural light, and can make the illumination of the classroom working surface constant at about 500lx.

4. Conclusion

With the continuous investment in the field of education and scientific research in China, the popularity of multimedia classrooms and multimedia facilities as teaching conditions is increasing. However, compared with the traditional classroom, the multimedia classroom is affected by the use of teaching equipment, and usually changes the indoor lighting and lighting environment during teaching activities, which makes the indoor lighting environment of multimedia classroom not very ideal, exposing many college students' visual and physical and mental health problems related to this, and the impact has become a social problem that can not be ignored. At present, it is necessary to carry out the research on the light environment of multimedia classrooms in Colleges and universities in China. Based on College Students' subjective use of multimedia classroom light environment, this paper collects, arranges and analyzes the relevant literature of multimedia classroom light environment, summarizes and discusses the influence of multimedia classroom light environment on students' vision, physiology, psychology, learning efficiency and the development of healthy lighting, energy conservation and environmental protection in China In the research of optical indicators, it is found that the research on the evaluation of classroom light environment quality based on brightness index has gradually attracted attention, but there is no quantitative research on its specific impact, which makes it impossible to judge and measure the impact of indoor light environment on students' visual clarity and visual comfort. The threshold values of visual clarity and visual comfort in the light environment of multimedia classroom are calculated, and the curve regression is carried out to find out the brightness range and influence trend of visual clarity and comfort in the light environment of multimedia classroom. The results of this study can provide a basis for the formulation and revision of relevant specifications in the future, and provide a reference for the light environment design of multimedia classrooms in Colleges and universities in China.

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