

An Efficient ILACS Control Algorithm for Intelligent LED Indoor Lighting System

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Abstract— in this paper, we propose an efficient Indoor Light Automatic Control System (ILACS) control algorithm for intelligent LED indoor lighting systems. The proposed ILACS control algorithm includes elements such as daylight intensity measured through a PIR sensor and an illuminance sensor at lighting style by a defined schedule and occupancy detection. This algorithm controls lighting through a wireless sensor network, and was designed for energy savings. Also, the algorithm controls indoor lighting based on occupancy detection of fine movements using a PIR sensor. Unnecessary lighting intensity control of the window-side and the inside were controlled according to daylight level measurements using the light sensor. In many cases of daylight inflow, the window-side lighting automatically became darker, and in daylight inflow, this occurred less, as the system was designed to be automatically bright. The efficiency validation results confirmed an efficient ILACS control algorithm for intelligent LED indoor lighting systems. The brightness of the indoor lights were employed to maximize the energy savings by controlling the system in real time when entering, in order to utilize external lighting or daylight.

Keywords— Sensor network, PIR, Daylight, ILACS, Control algorithm

I. INTRODUCTION

The expected purpose of lighting in modern society is not only to serve as a light source for providing illumination, but light is also expected to be environmentally friendly. The need for high-efficiency lighting systems for saving energy has been increasing, because energy is finite and environmental factors are becoming increasingly important [1-2].

As a method for power saving, it is possible to confirm the active state of the light by an administrator input, and to operate by introducing a power management system. The operating method by administrator is not efficient, because it is necessary to manage the system while frequently surveying the room. Also, installation costs for a separate wiring system are required, and additional equipment to operate the power management system by wire is required. Therefore, it is necessary to develop a system that can be managed wirelessly. The lighting control system based on wireless sensor networks is identified as an important factor in order to allow the application to daily life, including purposes such as building and home automation. It is straightforward to apply these

systems indoors, because adjusting the light intensity is simple in these environments. Also, there is a problem related to merely increasing the efficiency of work and research, business [3-7].

In this paper, we propose an efficient ILACS algorithm for intelligent LED indoor lighting systems to improve the problem related to lighting control systems of the existing simple effect involving the introduction of a daylight lighting control system. The proposed automatic control algorithm controls the light by using wireless sensor networks that include the daylight intensity that is measured by the PIR sensor and a light sensor for lighting style according to the schedule definition and occupancy detection.

II. INDOOR LIGHT AUTOMATIC CONTROL ALGORITHM

The efficient ILACS control algorithm for an intelligent LED indoor lighting system proposed in this paper is an algorithm for automatically monitoring indoor lighting and control; with this algorithm, it is easy to perform luminaire maintenance and expansion of new luminaires. Because it is possible to control extensive indoor lighting systems individually or in groups by using multi-transmission and ZigBee schemes, it is possible to ensure system stability of all configured devices by using the distributed control function. An indoor location-specific illumination distribution provides accurate prediction that is possible through control of the indoor lighting by natural light. This can be calculated as the indoor electrical energy reduction through the dimming of indoor lighting used incidentally to maintain the recommended roughness in accordance with the intended use indoors.

In this paper, the indoor lighting automatic control method used in the proposed ILACS control algorithm was separated as blink control for daylight environments and pattern control that is dimmable. The blink control is easy to install and maintain, because it determines the blink of the indoor lighting according to the appropriate range of the pre-injected daylight. However, indoor illuminance occurs by a radical change via dimmable blink pattern control. Using this method, it is possible to keep the room precisely at the desired level of illumination, and it is easy to install and maintain. This method controls the output light intensity of the LED lighting

fixture by controlling the power fed to the light, which is used to change the daylight amount entering the indoor space.

The ILACS control algorithm was applied to an intelligent LED indoor lighting control system to achieve energy efficiency. Experimental conditions were applied to the group control and dimming control, individual control, permanent lighting control, lighting control by schedule, and occupancy sensor. Figure 1 shows the ILACS control algorithm. When operated on ILACS, the algorithm is the selected control method for setting the indoor illumination. If the control method is selected according to the schedule, it determines the schedule by checking the current time zone. It determines the light level by measuring the indoor illuminance through daylight and ambient light sensor calculations. Also, the algorithm controls the lighting device as a set-group using a lighting pattern through the determined light level. If it is not finished when the schedule is checked, the lighting control will be repeated according to the schedule. Otherwise, the lighting control will be terminated. The lighting is controlled by the illumination schedule according to the time and day of the week input to the gateway. This method can be employed to achieve greater efficiency. That the on/off by pattern lighting and at the management aspect by dimming control.

If selecting the control method according to occupancy detection, it should be confirmed whether the occupancy will be used by the PIR sensor. If the occupancy is not detected, the lighting control is terminated. If occupancy is detected, the lighting level is determined by measuring the indoor illuminance through daylight and ambient light sensor calculations. And the lighting device controls the lighting in the set-group using the light pattern according to the determined lighting level. Also, if the detected motion is indoors and is detected by the motion sensor, the lighting control is repeated by occupancy detection. Otherwise, the control ends. Finally, the algorithm confirms the shut-down status of the system, and the lighting control is repeated by selecting the control method or ending the ILACS.

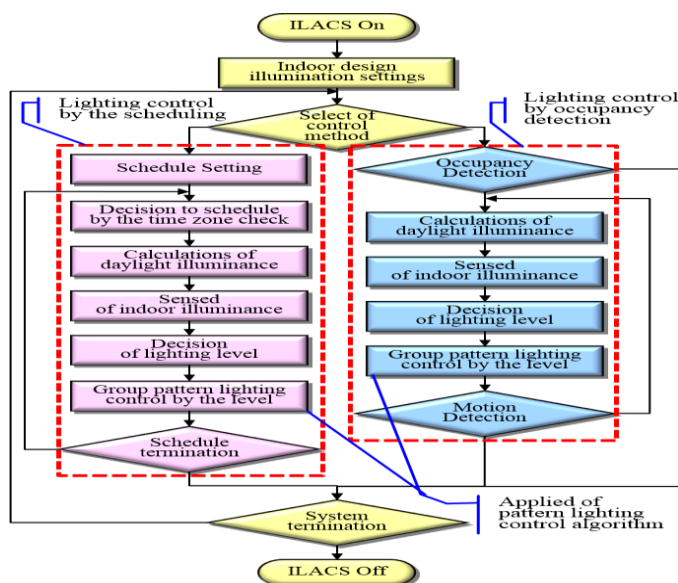


Figure 1. ILACS control algorithm

III. EXPERIMENTAL RESULTS

In this paper, we set up a test environment of Linux lighting simulation tools for the efficiency evaluation of an efficient automatic control algorithm for intelligent LED indoor lighting.

Figure 2 shows the experimental environment of the indoor lighting system that applies the ILACS algorithm. Into the management system was installed an indoor light control program, and a passive infrared sensor and a light sensor were used. Distribution boxes are composed of ZigBee modules and gateways for each group, the ZigBee communication, and lighting control. Each group was composed of the ZigBee module and the LED drivers, the LED down light, and the LED flat lighting.

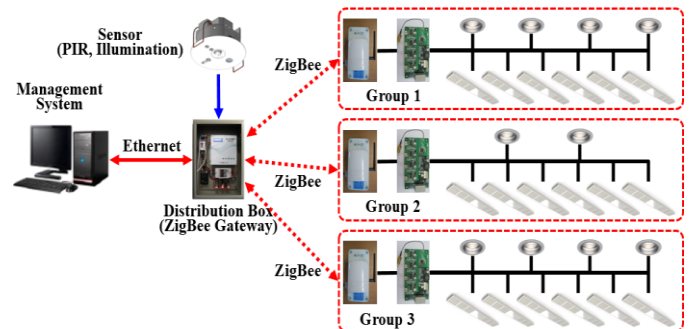


Figure 2. System Experimental environment

Figure 3 shows the experimental conditions for the simulation. The experimental conditions through the experimental environment were established by the group control according to daylight inlet and occupancy sensing. The dimming control was set up according to the inflow of daylight, the lighting control by schedule, individual control, the lighting control by the occupancy sensor, and the separate, permanent lighting control. Figure 2 shows the experimental conditions for the simulation.

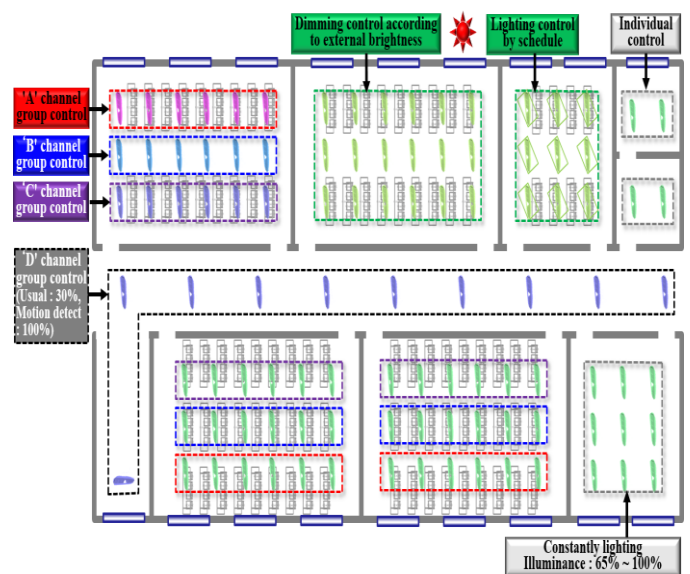


Figure 3. Experimental conditions for the simulation

Figure 4 shows a simulation result of group control by the influx daylight and occupancy detection of the proposed ILACS control algorithm in this paper. Measurement results of indoor illumination by daylight and LED lighting could be obtained at an average 328 lx and 237 lx. Here, the relative errors were shown to be 4.5% and 5.20%, respectively. The indoor illuminance of the ceiling by the indoor lighting control system could be obtained as the results of the measurements of an average 537 lx. In the planning phase of the lighting control system, by using natural light through the indoor illuminance, a distribution prediction could be confirmed that the pre-performance evaluation according to the characteristics and specifications of the indoor system is possible.

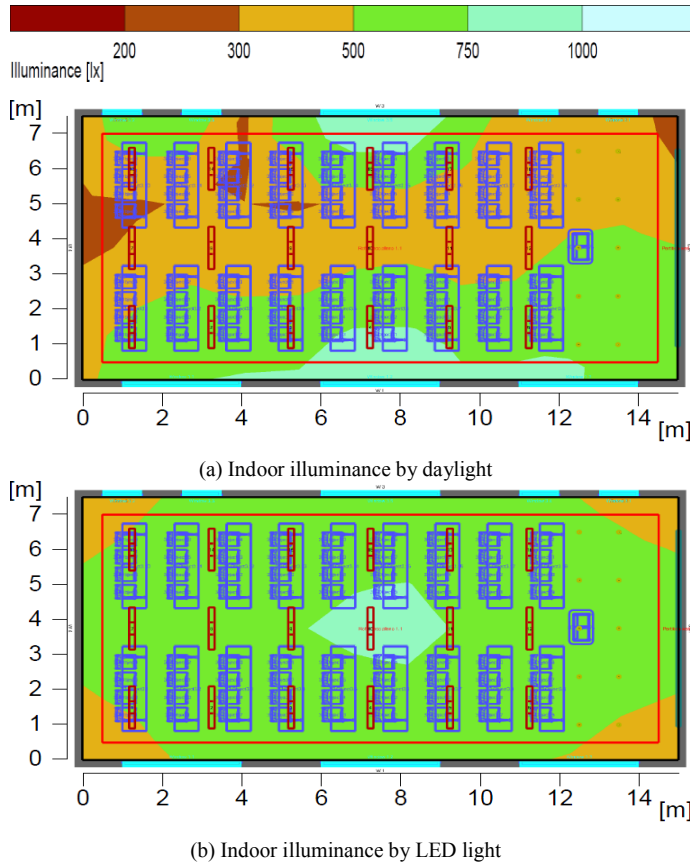


Figure 4. Illuminance measurement result

Table 1 shows a comparison of power consumption simulation results of fluorescent and LED lighting. The intelligent LED indoor lighting control system consumed 93,440KW of power annually when the fluorescent lamp was used, but this consumption can be reduced to 52,560KW annually when the LED light is used. The power consumption can be reduced to 31,536KW annually when an efficient automatic control algorithm for intelligent LED indoor lighting is applied. As a result, we were able to reduce the power consumption by up to a maximum of 66.25%. Table 2 shows a comparison of the energy savings for the fluorescent lamp and the LED lights. The energy cost was reduced annually by \$252,957.

TABLE 1. COMPARING OF POWER CONSUMPTION SIMULATION RESULTS

	Design capacity	Before	After	
		Fluorescent light	LED Lighting	System introduction
capacity	32W X 2	32W X 1	18W X 1	18W X 1
hr	8	8	8	8
ea.	1,000	1,000	1,000	1,000
used days	365	365	365	365
KW	186,880	93,440	52,560	31,536

TABLE 2. ENERGY SAVINGS COSTS

Lamp type	Power Consumption	Usage Period		
		1 year	2 year	3 year
Fluorescent light	32W	\$562,366	\$1,124,732	\$1,687,098
LED lighting	18W	\$309,409	\$618,818	\$928,227
Reduced costs		\$252,957	\$505,914	\$758,871

IV. CONCLUSIONS

In this paper, we proposed an efficient ILACS control algorithm for intelligent LED indoor lighting to improve the problems found in existing lighting control systems related to simple functionality with the introduction of a lighting control system that uses daylight. The proposed ILACS control algorithm was applied to the best possible lighting system in the design phase of the building. If external lighting or daylight was used in the room, we were able to maximize energy savings in real time by controlling the room lighting brightness. In the future, a study should be conducted to develop a light control system that constantly maintains a natural light plan and indoor illumination distribution.

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