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Intelligent Home and Office LED Lighting System Considering Energy Efficiency and Environmental Conditions

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Abstract: Saving electrical energy has become one of the most important problem facing in now a days . The most waste of energy is caused by the inefficient use of the user electronic devices. specifically a light accounts for a great part of the total energy consumption. many light control systems are introduced in light system market, because the installed lighting systems are out-dated and more energy consumption. because of the reason of architectural limitations, the existing light control systems consume more power in home and office buildings lightning system. Therefore, this paper proposes an intelligent home and office LED lighting system with energy efficiency and user environment. The proposed system utilizes multi sensors and wireless communication technology to control an LED light according to the user's location and the surroundings. The proposed LED lighting system can automatically adjust the minimum light intensity value to enhance both energy efficiency and user convenient. We designed and implemented the proposed system in the test bed and measured total power consumption to verify the performance.
Keywords: **Light intensity control ,user location tracking ,wireless network ,led light control system**

I.INTRODUCTION

Energy-saving solutions have been becoming increasingly essential in recent years because of environmental issues such as climate change and global warming Environmental problems are very important issues and these problems are largely caused by the excessive use of energy. A light accounts for approximately 20 percent of the world's total energy consumption; thus the related studies of an energy efficient lighting system have been done by various researchers around the world. The invention of a light emitting diode (LED) is expected to significantly alleviate the energy consumption, because the LED lighting device consumes 50 percent of the energy consumption compared to the fluorescent lighting device.

The intelligent lighting control system can reduce energy consumption by controlling the intensity of illumination through environmental conditions, such as awareness of user movement or brightness of certain area.. The technical report from the U.S. Department of Energy displays that about 15 percent of total energy consumption can be reduced through light control according to user's environmental conditions such as total brightness condition, light intensity requirement for the rooms . However, since the existing lighting control systems can support only simple on/off or dimming control according to user movement or brightness of environment, it is difficult to be applied to complex environments such as house, office ,living room,hall etc. The complex environment means that there is a variety of control needs, because of the presence of a variety of users. Because of this limitation of the present light control system, they are mostly installed in the places such as the front door or the hallway. Furthermore, since the present light control system are designed without considering user environmental and location conditions, it is not appropriate to the places such as house,office ,work station and seminar halls. where user satisfaction is more important than cost benefits due to energy saving; thus a new intelligent lighting control system should be designed considering both energy efficiency and user satisfaction.

The new intelligent light control system required the following factors :

-should have maximum utilization of the LED

-should have well communication network.

-should be designed with control based situation awareness

-should have efficient energy control with user satisfaction.

II. PROPOSED INTELLIGENT HOUSEHOLD LIGHTING

The intelligent house and office LED lighting system requires a motion detection sensor, illumination sensor, and wireless communication interface. Before presenting the proposed system with system architecture and important scheme, the problem of the lighting system should be studied.

A. Problem Description

Fig. 1 illustrates the basic operating principles of theproposed system. The system control and state variables are:

Lmin minimum light intensity;

Lmax maximum light intensity;

T_r rise time period of the light intensity;

T_m time period between no movement detection

and that the light intensity begins to falls;

T_f fall time period of the light intensity;

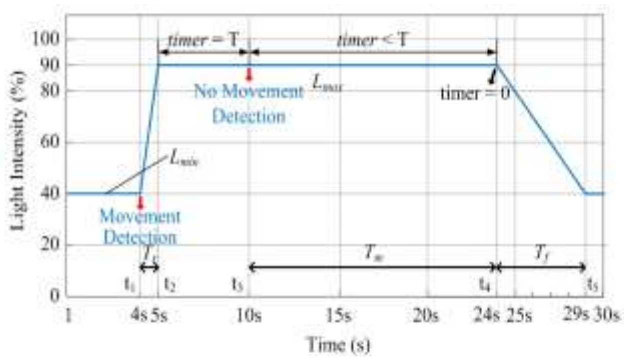

fig .1 Basic operating principles

The proposed system basically controls illumination intensity of a lighting device according to user movement and brightness of surroundings. when the maximum value of illumination intensity of a lighting device is Lmax and the minimum value is Lmin, the illumination intensity becomes Lmax, if user movement is detected and becomes Lmin, if user movement is not detected for certain period time. As shown in Fig. 2, it can be confirmed that as Tr is longer, Tm and Tf are shorter, and Lmax and Lmin are smaller, the energy saving effect becomes larger. However, it implies the possibility that inconvenience of users can be bigger because of frequent light on/off, and dark indoor environment, etc. whereas the energy saving effect becomes larger. Therefore, it is necessary to properly set the value according to space environmental characteristics (frequent or rare user movement, work type, etc.).

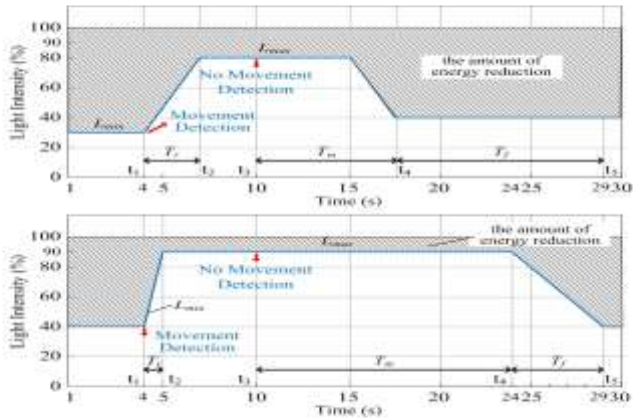

fig 2 Comparison of the amount of energy reduction according to *Lmax*, *Lmin*, T_r, T_m, and T_f.

B. Overview of IHLS

We propose an intelligent house and office LED lighting system using various sensors and wireless communication technology. Fig. 3 shows an overview of the proposed lighting system. The main features are as follows:

• Automatic control based on user movement

• Automatic control based on brightness of the room

• Automatic optimization of system control and state

Variables

• Collective control using a wireless technology

• Control and system setting through a wireless controller.

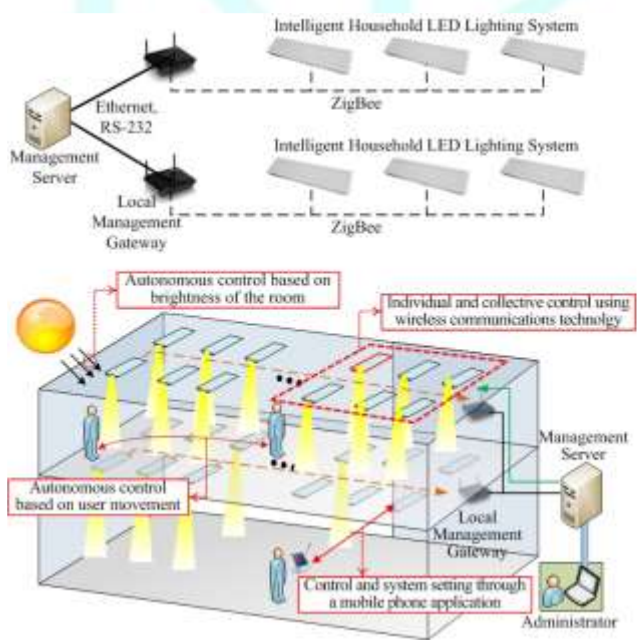

Fig.3 The wireless sensor arrangement and the overview of the system.

The proposed system can reduce energy consumption via interaction with the information about user's state and surroundings (e.g. brightness of a room). The automatic control could lead to disturbance to residents. Thus, the proposed system automatically optimizes the system control and state variables, especially Lmax, Lmin, Tr, Tm, and Tf in order to enhance both efficient energy control and user satisfaction.

C. Minimum Light Intensity Control Algorithm:

The signal of inconvenience is received from residents through a smart phone when they feel the brightness of the lighting with inconvenience. The countdown timer can interrupt the system after a given amount of time has expired.

The proposed minimum light intensity control algorithm automatically adjusts Lmin based on the signal of inconvenience of users, which are inputted via smart phones. The value of illumination intensity of the lighting that has been felt with inconvenience at the latest is Lminincon, whereas the value of illumination intensity that has not been felt with inconvenience for a certain period of time, T at the latest is Lmincon. The initial Lmin0, and Lminincon is set to zero, and the initial Lmincon is set to Lmax. The procedures are composed of five steps.

Step 1. First, check whether a signal of inconvenience has occurred. If a signal of inconvenience has occurred, then Lminn = (Lmincon+Lminn-1)/2, Lminincon = Lminn-1, n = n + 1, and timer = T. And then check again whether a signal of inconvenience has occurred.

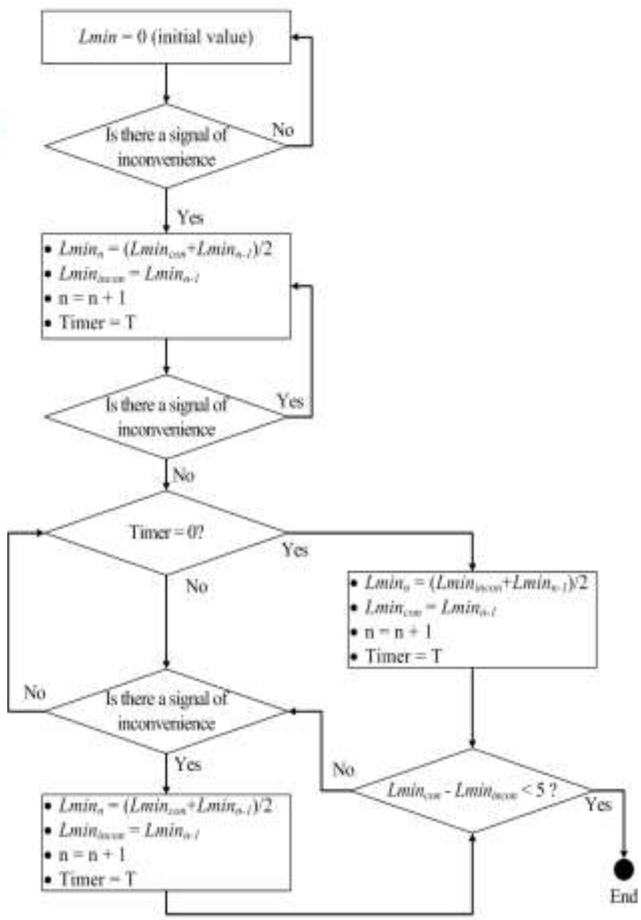

Fig.4 The minimum light intensity control flow chart.

Step 2. Check whether a signal of inconvenience has occurred. If a signal of inconvenience has occurred, then Lminn = (Lmincon+Lminn-1)/2, Lminincon = Lminn-1, n = n + 1, and timer = T as in Step 1. If a signal of inconvenience has not occurred, then check whether timer is equal to zero (i.e. the expiration of a given amount of time, T).

Step 3. Check whether timer is equal to zero, if timer is equal to zero, then Lminn = (Lminincon+Lminn-1)/2, Lmincon = Lminn-1, n = n + 1, and timer = T. And then, check whether Lmincon minus Lminincon is less than 5 or not. If timer is not equal to zero, check again whether a signal of inconvenience has occurred.

Step 4-1. After check whether Lmincon minus Lminincon is less than 5, if Lmincon minus Lminincon is less than 5, then terminate this flowchart. If Lmincon minus Lminincon is not less than 5, then perform the process of Step 4-2.

Step 4-2. Check whether a signal of inconvenience has occurred. If a signal of inconvenience has occurred, then Lminn = (Lmincon+Lminn-1)/2, Lminincon = Lminn-1, n = n + 1, and timer = T. If a signal of inconvenience has not occurred, then perform again from Step 3.

It is possible to derive the value of Lmin, which can saveenergy at the maximum without causing inconvenience for users through the proposed algorithm.

D. Middleware Architecture

As for the conventional LED lighting products, they should be developed using the low-cost MCU in order to reduce the production unit price; thus, they have a disadvantage of having the limited availability space of the computing resources or storage resources. To solve this problem, we design the platform of adaptive middleware that can update an internal program through the automatic control or the remote control by an administrator in accordance with the external environmental changes. The adaptive middleware platform is composed of the LED control module group, which performs the role of controlling LED, the adaptive middleware group, which can change through the external environment or the remote command of the administrator, and the table group, which manages a variety of data used for context awareness and LED control.

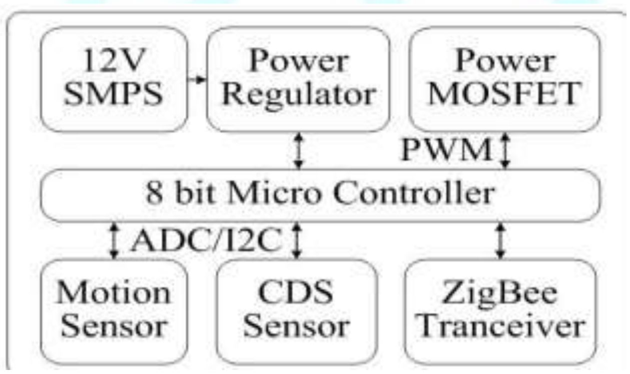

Fig.5 block diagram of proposed system.

1) LED Control Module Group

Network Module: It is the module related to the ZigBee and RS485 serial for communication with the external control system. This module processes interrupts and message for communications

Manager Module: It internally processes the control command, which is transferred from the manager of the adaptive middleware group and converts it into a form for communications and control, and has the role of managing the conflict or loss of the transferred messages.

PWM Module: It performs the role of generating and stabilizing the PWM signal for LED control. It also performs the role of generating the signal to control an actual LED based on the data transferred from the adaptive middleware and retrieved from the table group.

2) Adaptive Middleware Group

Core Middleware: It is the module to possess the core function of the adaptive middleware. Basically, it is mainly used for the manager management, scheduling for managers, and access control of the table used by the managers. It registers and activates the managers upon receiving the control messages from the external management server. It also performs the role of deleting the existing managers in accordance with the commands transferred from the management server. In addition, it performs the role related to authentication for external management server.

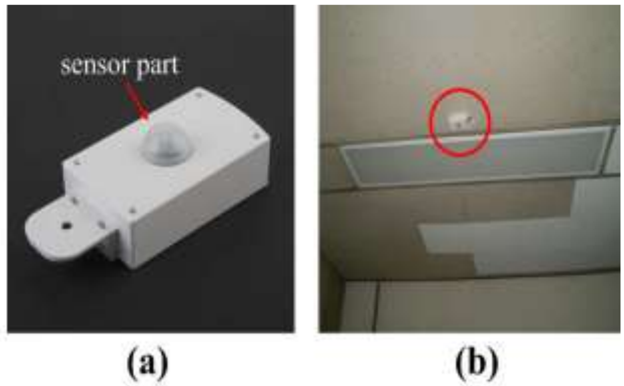

Fig.6 The proposed system (a) prototype ,(b) implementation

Manager Group: This group can registers and deletes the managers in the adaptive middleware group in real time. The illumination sensor manager performs the roles of gathering the value of intensity of illumination from the sensor or making the rule table for control upon receiving the data sensed from the sensor module, the neighboring lighting system, or the management server. In addition, this group is used for managing the value of illumination intensity of the internal parameter table. The time sync manager is the manager related to the time-based control. It plays a role in time synchronization with the external control system and making the rule table for time-based control or updating time information in the share table. The motion sensor manager plays the role in managing the information collected from the motion sensor in the same way as the illumination sensor manager.

3) Table Group

Rule Table: It stores the rule, which is the information for control. It is composed of the time-based and sensor-based rule, and it is connected with the PWM module.

Share Table: It is the table to store the information to be shared between the modules. It stores the necessary information to share, such as real-time sensing information or connection information with the management server.

Variable Table: It is the table to store the data of the variables to transfer information between the modules.

Parameter Table: It is the table to store the control and network status. It stores a variety of parameters such as network address, transfer schedule, transfer buffer, etc.

III. Implementation and Testbed

The main processor part uses 8 bit microprocessor. This part plays a role in situation analysis, event processing, and learning. This part optimizes the control and state variables to adapt itself to the various environments. The sensor part is composed of various sensors. To provide energy saving services mentioned above, two kinds of sensors, that is a motion detection sensor and illumination sensor are needed basically. A ZigBee (250 kbps/2.4 GHz) module is used for communication with other LED lighting system and networked devices. LED driver part consists of current controller modules for driving LEDs. There are two ports that are controllable and are able to control for 255 levels of brightness. The power part is composed of a power regulator and SMPS.

The proposed intelligent LED lighting system has eight switches as shown in Fig. 6, and it is possible to adjust the variable system control parameters, i.e. Lmax, Lmin, Tr, Tm, Tf, and countdown timer. When the switch g is On and the h is On, the switch a, b and c are used to adjust the maximum value of illumination intensity (Lmax), and the switch d, e, and f are used to adjust the setting of the minimum value of illumination intensity (Lmin).

Fig.7 pcb layout

When the switch g is On and the h is Off, the switch a, b, and c are used to adjust the rise time period (Tr), and the switch d, e and f are used to adjust the fall time period (Tf). When the switch g is Off and the h is On, the switch a, b, and c are used to adjust the countdown timer (Tm). If the switch g is Off and the h is Off, the proposed system operates as a general LED lighting without intelligent lighting control.

Experiment and Results:

In an experiment, we measured total power consumption for 14 days. Fig. 8 shows the result of an experiment. The proposed lighting control system reduces energy consumption up to approximately 21.9%.

IV. Conclusions and Future Works

Saving energy has become one of the most important problem . A light accounts for approximately 20 percent of the world's total energy consumption; However, since there are no products considering both energy efficiency and user satisfaction, the existing systems cannot be successfully applied to home and office buildings. Therefore, we propose an intelligent household LED lighting system considering energy efficiency and user satisfaction. The proposed system utilizes multi sensors and wireless communication system in order to control an LED light according to the user's state and the environmental conditions. The proposed system can autonomously adjust the minimum light intensity value to enhance both energy efficiency and user environmental condition.

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