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RESEARCH ARTICLE

Intelligent LED Lighting System for Energy Efficiency

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Abstract:

In the recent trends the use of electronic load is increasing very fast and the gap between demand and supply have made the reliability and power quality a critical issue. The most waste of energy is caused by the inefficient use of the consumer electronics. Particularly, a light accounts for a great part of the total energy consumption. Various light control systems are introduced in current markets, because the installed lighting systems are outdated and energy-inefficient. However, due to architectural limitations, the existing light control systems cannot be successfully applied to home and office buildings. Therefore, this paper proposes an intelligent household LED lighting system considering energy efficiency and users satisfaction. The proposed system utilizes multi sensors and wireless communication technology in order to control an LED light according to the users state and the surroundings. The proposed LED lighting system can autonomously adjust the minimum light intensity value to enhance both energy efficiency and user satisfaction. We designed and implemented the proposed system in the test bed and measured total power consumption to verify the performance. The proposed LED lighting system reduces total power consumption of the test bed up to 21.9.

Key Words: PGPR, RBD

Introduction

Energy-saving solutions have been becoming increasingly essential in recent years because of environmental issues such as climate change and global warming [1]-[4]. Environmen-tal 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 worlds total energy consumption [5]; thus the related studies of an energy efficient lighting system have been done by various researchers around the world [7]-[14]. The invention of a light emitting diode (LED) is expected to significantly alleviate the energy consumption of a light, because the LED lighting device consumes 50 percent of the energy consumption compared to the fluorescent lighting device. Recently, an intelligent lighting control system using various sensors and communication mod-ules are actively studied and developed in both university and industry [6]. The intelligent lighting control system can reduce energy consumption as automatically controlling the intensity of illumination through situation awareness, such as awareness of user movement or brightness of surroundings. The technical report from the U.S. Department of Energy shows that about 15 percent of total energy consumption can be reduced through light control according to user’s living pattern.

There are many researches on the lighting control system. Pan et al [7] proposed a wireless sensor network-based in-telligent light control system for indoor environments. This light control system manages lighting devices according to user’s activities and profiles. Two algorithms (Illumination decision algorithm and device control algorithm) are proposed to meet requirements of the user and to save energy. Uhmet al[8] proposed an LED light system with light sensors, motion sensors, and network interfaces. This light control system can control illumination intensity of an LED light based on brightness of surrounding and movement of residents. Park etal [9] presented lighting control system based on a building automation and control network (BAC net). Matta et al [10] proposed a light control system with detailed design for energy saving by controlling the intensity of illumination. In this paper, a logical low cost design is introduced to conserve electrical energy taking daylight illumination into consideration by using a controller area network (CAN) bus as the media for communication. Bellido-Outeirino et al [11] presented building lighting automation system using digital addressable lighting interface (DALI) devices with wireless sensor networks. There are some researches about street light-ing control systems. Leccese [12] proposed remote control system can optimize management and efficiency of street lighting systems. It uses ZigBee communications which enable more efficient street lamp-system management.

There are some researches about evaluation of energyef-ficiency of lighting systems. Delaney et al [13] proposed a wireless sensor network as a evaluation tool that can help in analyzing and evaluating the energy-efficiency of an existing lighting control system in a low-cost. Denardin et al [14] presented an intelligent street light controlling and monitoring system based on a wireless data network. This system add communication capabilities to the existing street light-ing systems through the integration of a ZigBee compatible transceiver in order to turn each street lighting system in to a node of a large wirelessnetwork.32-bit ARM processor is the contemporary general purpose microprocessor in the embedded market used in industrial level applications. GSM, as we know, is the most widely used mobile Technology. Using a simple Subscriber Identity Module (SIM), it has taken the world of mobile communication to new heights. It is based on a simple architecture. Even with the introduction of new technologies like CDMA, GSM has stood its strength due to its efficiency and simplicity. Atomized irrigation is an interesting application. Primarily for Real time atomization of agricultural environment for social modernization of Indian agricultural system.

The lighting control system for energy savings in current markets can support on-off and dimming control as managing lighting devices after detecting an object or intensity of illumi-nation, or controlling with time setting. Furthermore, although most existing systems have variable control parameters, it is difficult for users to modify these parameters, so that it is not appropriate to be applied in various places. In addition, although the lighting control system using central management server or sensor networks was studied recently, it was not commercialized or industrialized, and even the commercialized products were excessively concentrated to the central manage-ment server.

II. SYSTEM DESIGN MODEL

This paper proposes an intelligent household LED lighting system considering energy efficiency and user satisfaction. The proposed system utilizes multi sensors and wireless communi-cation technology in order to control an LED light according to the users state and the surroundings. The proposed LED lighting system can autonomously adjust the minimum light intensity value to enhance both energy efficiency and user satisfaction.

A. Hardware Section

The prototype and hardware block diagram of the proposed system. The main processor part uses 32-bitmicroprocessor. 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 255levels of brightness. The power part is composed of a power regulator and SMPS.

The proposed system basically controls illumination inten-sity of a lighting device according to user movement and brightness of surroundings. That is, 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. There are many people in a home and office building; thus, user satisfaction is an important factor in the light evaluation. In these places, Lminis set according to the proposed minimum light intensity control algorithm. Generally, Lmin is set to the high value in these places.

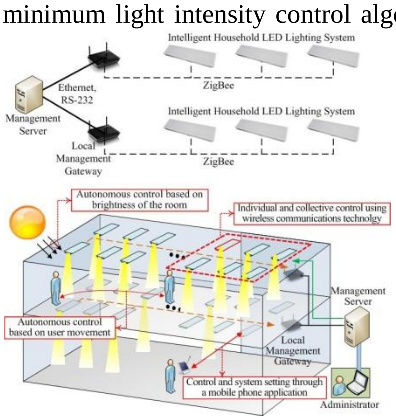

Fig. 1. Overview of the proposed system

III. SOFTWARE SECTION

This is an Operating System (OS) on which all the software applications required for our design are going to be run. This OS is flexible to any user to operate and easy to understood. Accessing the soft wares and using them is very convenient to user. Or-CAD is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly to create electronic prints for manufacturing of printed circuit boards, by electronic design engineers and elec-tronic technicians to manufacture electronic schematics. The Vision development platform is easy-to-use and it helps you quickly create embedded programs that work. The Vision IDE (Integrated Development Environment) from Keil combines design management, source code editing, program debugging, and complete simulation in one powerful environment. Code written in EMBEDDED C.

IV. MINIMUM LIGHT INTENSITY CONTROL ALGORITHM

Fig. 3 illustrates a flowchart of a minimum light intensity control algorithm that requires a signal of inconvenience and a countdown timer. 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.

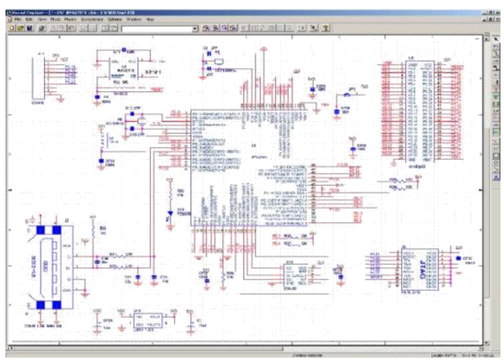

Fig. 2. Overview of the proposed system

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.

Step 2. Check whether a signal of inconvenience has oc-curred. 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, Lmin-con = 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 save energy at the maximum without causing inconvenience for users through the proposed algorithm.

V. IMPLEMENTATION AND TESTBED

A. Implementation

Fig. 4 shows the prototype and hardware block diagram of the proposed system. 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.

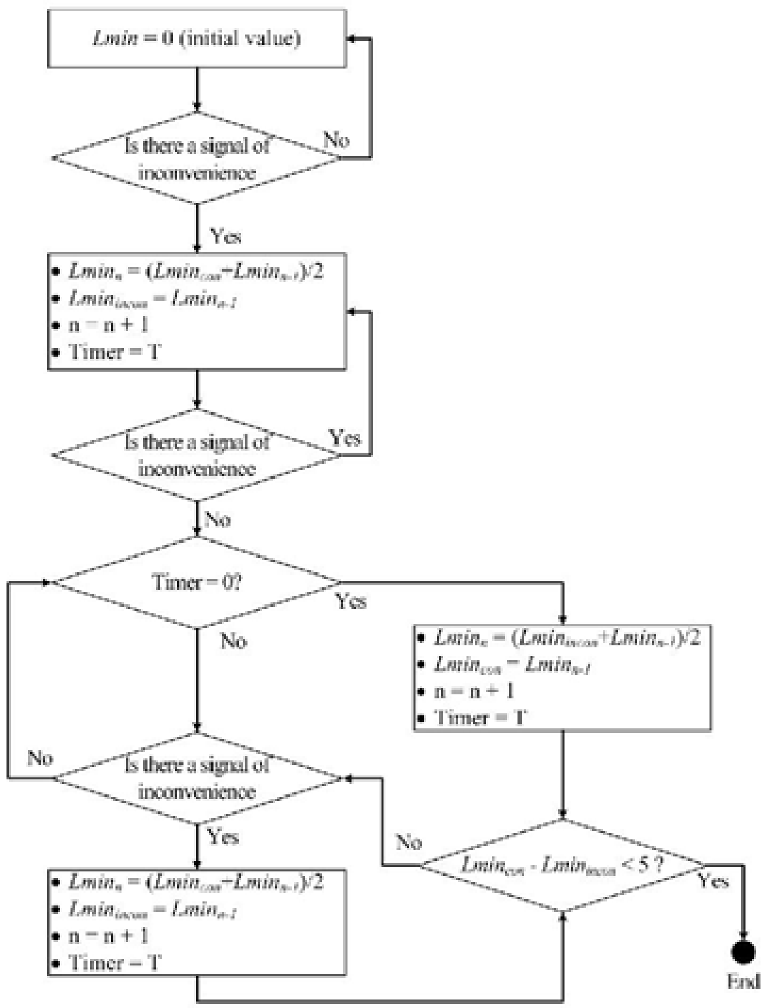

Fig. 3. flowchart of a minimum light intensity control algorithm

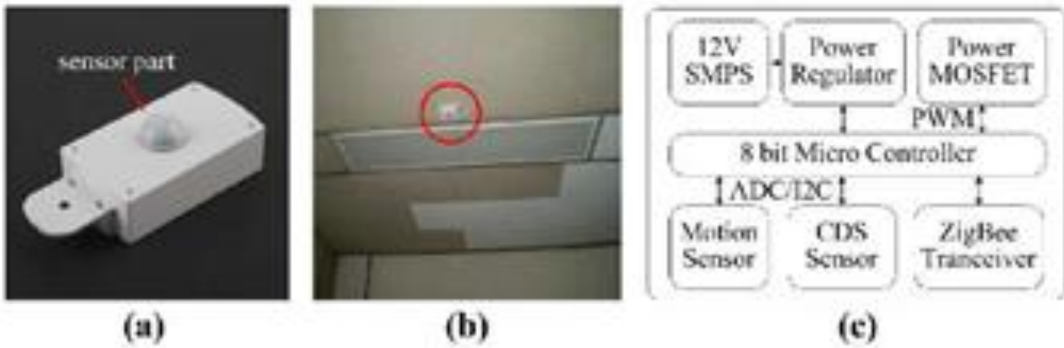

Fig. 4. Implementation of the proposed system; (a) prototype, (b) installation, (c) hardware block di

B. Testbed

Fig. 5 shows a floor plan of a test bed with the illumination simulation result. There are 44 LED lights (42-watt light) with the proposed system.

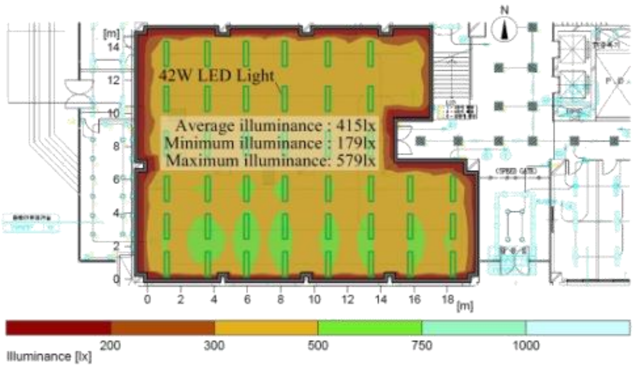

Fig. 5. Floor plan of a test bed with the illumination simulation result

VI. CASE STUDY

A. Home and office building

There are many people in a home and office building; thus, user satisfaction is an important factor in the light evaluation In these places, Lmin is set according to the proposed minimum light intensity control algorithm. Generally, Lmin is set to the high value in these places.

B. Warehouse

There are a few people in a warehouse; thus, user satisfac-tion is a less important factor than the case of a home or office building. Generally, in the warehouse, Lmin is set to the low value. In this case, a significant amount of energy consumption can be reduced.

VII. CONCLUSION

Saving energy has become one of the most important issues these days. A light accounts for approximately 20 percent of the worlds total energy consumption; thus, a lot of studies and development related to energy saving of a light have been done by various researchers all over the world. 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 technology in order to control an LED light according to the users state and the surroundings. The proposed system can autonomously adjust the minimum light intensity value to enhance both energy efficiency and user satisfaction We designed and implemented the proposed system in the test bed and measured total power consumption. The proposed lighting system reduces total power consumption of the test bed up to 21.9

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