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INTELLIGENT LIGHTING SYSTEM WITH ENERGY EFFICIENCY

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ABSTRACT

This paper describes Intelligent Lighting System to reduce energy consumption in lighting system. Now days' saving energy is the most important issue, so many light control systems have been initiated in current market. But due to some designing limitations and energy inefficiency, the existing light control systems cannot be successfully installed in home and office buildings with energy efficiency and user satisfaction. This system uses motion, light sensors and wireless communication technology for control and monitors an LED light according to the user's movement and the surrounding light. This system can automatically adjust light intensity to improve energy efficiency and user satisfaction. The android Bluetooth application is particularly designed to control minimum light intensity as per user need and environment light illuminance.

KEYWORDS: Light illuminance, wireless communication technology, Bluetooth, minimum light intensity.

INTRODUCTION

Energy crisis is one of the biggest challenges to whole world in recent years. Energy-saving solutions are essential in today's world because of environmental issues such as climate change and global warming. These environmental issues are very critical and these problems are mostly due to the excessive use of energy. The light units make large part of energy consumption all over the world.

The energy consumption by the light units is cannot be ignored as these units consumes about 20% energy of world's total energy consumption [1]. Thus lot of work, studies and development is going on related to energy efficient lighting system. The innovation of a Light Emitting Diode (LED) is significantly attenuating the energy consumption of a light. This is because the LED lighting device consumes half energy as compared to energy consumption of fluorescent lighting device.

Today vigorous research and developments are going on in multiple universities and industries to develop and intelligent lighting control system using multi sensors and wireless communication module [2]. The intelligent lighting control system can bring down energy consumption by controlling the intensity of light through situation awareness. Situation awareness is user movement and surrounding light illumination. 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 [3].

Light units are usually control by switches. The user can switch a light ON or OFF remotely by connecting a specific device to a server, but in this control mechanism, server consumes large amount of power in a day [4-5]. Generally users need different light intensities in different places. Sometimes the light intensity of surrounding is sufficient, and user has no need to turn on light. But sometimes the user leaves the place but forgets to turn off the light. Hence this causes wastage of energy. Therefore some power management of light control in a home is needed in order to save energy. The existing lighting control systems can support only simple on/off or dimming control of light according to

user movement and brightness of surrounding light. This system is difficult to apply to complex environments such as house or office. In complex environment numbers of controls are required, because numbers of user are there. This is drawback of existing systems, so these systems are generally installed on front door or hallways. The existing lighting control systems are designed without user satisfaction keeping in mind. These systems are not suitable to the places such as house and office, because house and office user satisfaction is more important factor than cost benefits due to energy saving. This system should be designed bearing in mind both energy efficiency and user satisfaction.

Considered all these things, objectives of intelligent lighting control system are given below:

- (a) The new intelligent lighting control system should be designed to intensify energy efficiency and user satisfaction.
- (b) The new intelligent lighting control system should be designed to make large use of LED.
- (c) The new intelligent lighting control system should be designed to control light unit on the basis of situation awareness.
- (d) The new intelligent lighting control system should be designed to have communication capability.

Hence, this an intelligent LED lighting system that has the capability to provide both energy efficiency and user satisfaction. The intelligent lighting control system uses motion, light sensors and wireless communication technology in order to control and monitor an LED light depending on the user's state and the surrounding light. This intelligent lighting control system can automatically adjust light intensity as per surrounding requirement. This system also adjust as per user requirement by wireless communication system. In this way intelligent system fulfills the requirement of user and increase energy efficiency.

This paper is organized as follows: in section II we discuss intelligent lighting system; in section III we discuss results of Intelligent Lighting System; in section IV conclude intelligent LED lighting system.

INTELLIGENT LIGHTING SYSTEM

The intelligent lighting system design consists of a pyroelectric infrared motion detection sensor, light detection sensor, and wireless communication interface.

A. Basic operating principle of Intelligent system

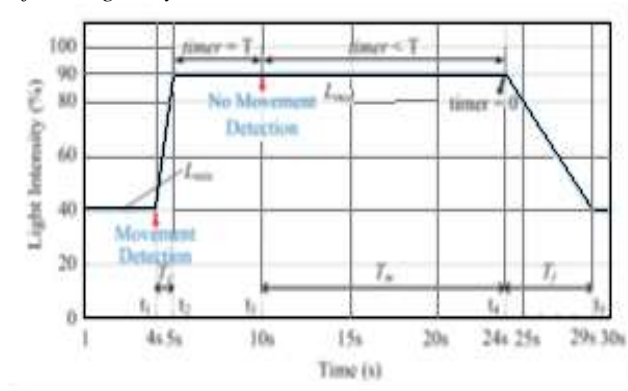


Fig 1: Basic operating principle of Intelligent system.

The intelligent lighting control system controls illumination intensity of light units with respect to user movement and brightness of surroundings. That means, when user movement is detected, light illumination intensity increases to maximum and if user movement is not detected for certain period time light illumination intensity becomes minimum or off. Frequently light on/off and dark indoor environment creates user inconvenience but it increase energy efficiency. Therefore it is necessary to set proper value according to environmental characteristics.

B. Overview of Intelligent Lighting system.

We have built an intelligent lighting system using various sensors and wireless communication technology.

The main features of intelligent systems are as follows:

- (a) The system automatically controls lights according to user movement.
- (b) The intensity of light is automatically adjusted with respect to surrounding light condition.
- (c) This system can autonomously optimize the system control and state variable in order to intensify energy efficiency and user satisfaction
- (d) User can control the system remotely through wireless technology. User can adjust the light intensity as per need. For this special mobile phone application is design.
- (e) This system is easy to operate, convenient and affordable.

C. Intelligent lighting control algorithm

The intelligent lighting control algorithm requires a signal of inconvenience. The signal of inconvenience is sent by user through a smart phone application when user wants brightness of lights as per his convenience. Below Fig shows Intelligent lighting control algorithm.

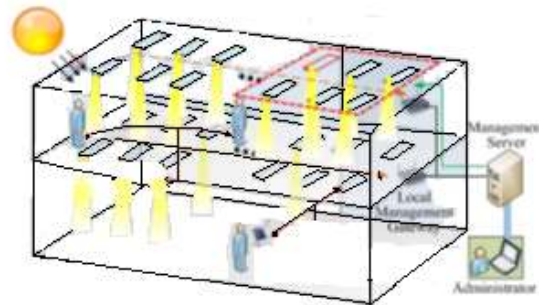


Fig 2: Overview of Intelligent system.

The Intelligent lighting control algorithm automatically adjusts *light intensity* according to inconvenience signal which is sent by users through smart phones. There are three types of mode of operation automotive mode, switch “ON” mode, and switch “OFF” mode. In auto mode lights are adjusted automatically as per user movement and surrounding light. In switch “ON” mode lights are on full intensity. In switch “OFF” mode lights get completely off. The signal of inconvenience is send via smart phone. User can adjust light intensity according to his/her convenience. The complete process is done in following steps.

- I. Firstly initialize all input output ports.
- II. Initialize serial communication and boud rate
- III. Initialize Interrupt value
- IV. Check whether any signal related to mode selection has occurred .Proceed according to mode selection signal.

For automotive mode:

- Check motion detection in both the room.
- According to status motion detection in either of room ,monitor surrounding light of that room. If surrounding light is sufficient, Calculate PWM accordingly and keep light switch off.
- According to status motion detection in either of room, monitor surrounding light of that room. If surrounding light is insufficient, Calculate PWM accordingly and keep light switch on .

For switch “ON” mode:

- In Switch on mode, lights are turn on with 100% duty cycle.

- In Switch off mode, lights are turn off by 0% duty cycle.

For signal of inconvenience

- Check whether signal of inconvenience has occurred. If signal of inconvenience has occurred, then adjust light intensity according to user need.

V. If signal has not occurred, then perform step IV.

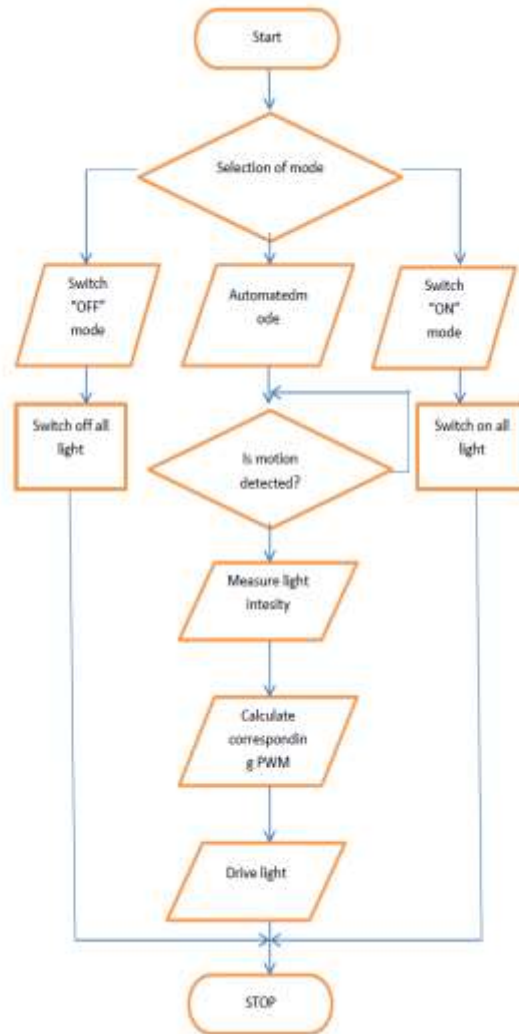


Fig 3: Flowchart of Intelligent Lighting control algorithm

D. Block diagram of Intelligent Lighting System

Fig shows basic block diagram of Intelligent lighting system.

In this system, Arduino board is used instead of microcontroller unit because MCU has limited availability of computer resources and storage resources, The PIR motion sensors, light illuminance sensors are connected to the board. The system can control and monitor through server also. The wireless Bluetooth communication technology is used in this system. The system is controlled and monitored using android phone.

Arduino board: Arduino board is open source prototyping platform based on easy-to-use having hardware and software. Arduino board is able to read inputs – light on sensor or a finger on a button and turn it into output - turning on LED or publish something online. Arduino board is inexpensive as compared to microcontrollers. Arduino software runs on Windows, Macintosh OSX, and Linux operating system.

PIR Motion sensor: PIR motion sensors are used to detect human being movement by detecting Infrared ray waves from human body. PIR has an Automatic Induction which gives high level output when person is in the induction range and gives low level output when person leaves the induction range. Motion sensors can be set photosensitive control, day or light intensity without induction. Motion sensor can be triggered in two modes - non-repeatable trigger and repeatable trigger. In non-repeatable mode, output turns to HIGH with a delay period; then output automatically turns to LOW level. Continuous motion results in repeated HIGH/LOW outputs. Output is LOW when not triggered. In repeatable mode, after it outputs HIGH level, during the delay time, if person is in the sensing range, the output remains HIGH until person leave, and then output goes to LOW level. Output is LOW when not triggered. There is a blockade time present in motion sensors after delay time over, during which any movement do not cause motion sensing.

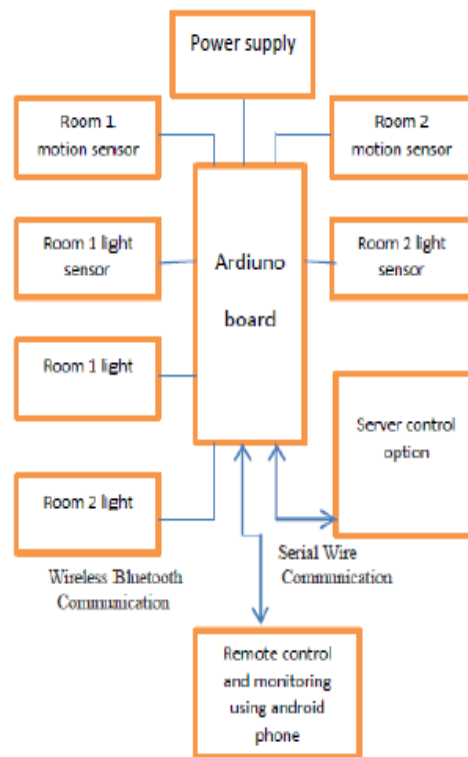


Fig 4: Block diagram of Intelligent Lighting System

Bluetooth module: Bluetooth serial module is used to set up communication between Arduino microcontroller and Bluetooth equipped device, such as laptops, tablet PCs or smartphones. Bluetooth serial communication module works in two modes: order-response mode and auto connection mode. And in auto connection mode, there are Master, Slave and Loopback work roles. When the module works in automatic connection mode, it automatically connects the other Bluetooth devices.

When the module works in the order-response mode, user can send the AT command to the module to set the control parameters and sent control order. The working mode of module can be change by controlling the module input level. **LDR:** Light Dependent Resistor is a light sensing device which has a resistance that changes with the light intensity falls upon it. It works on the principle of Photo conductivity. This allows LDR's to be used in light sensing circuits

i.e. automatically turning ON /OFF the lighting device at certain level. In dark, its resistance is very high, which can be as high as 1000000Ω, but when light intensity increases, resistance drops dramatically.

LED: Light Emitting Diode is a semiconductor device that emits light when current passes through it. LED lights require lower power supply, have super energy efficiency and have longer lifetime in comparison to incandescent light sources.

EXPERIMENTAL RESULTS OF INTELLIGENT SYSTEM

In Intelligent system Arduino board which plays the key role in situation analysis and event processing. Various sensors are required to provide energy saving solutions, that is motion detection sensor and light intensity detection sensor. Bluetooth module is used for communication between user and system. User can adjust the system mode as per need.

To calculate the efficiency of Intelligent lighting system over Normal lighting system, we have taken average of 30 samples of power consumption by both systems on a particular day over a period from 07.00 am to 17.00pm at an interval of 20 minutes. Fig 5 shows power consumption by Intelligent and Normal lighting system. We have followed the same procedure for 10 days to calculate average power consumption by both systems and we have found that average power consumed by Intelligent lighting system is approximately 73% in comparison to 100 %

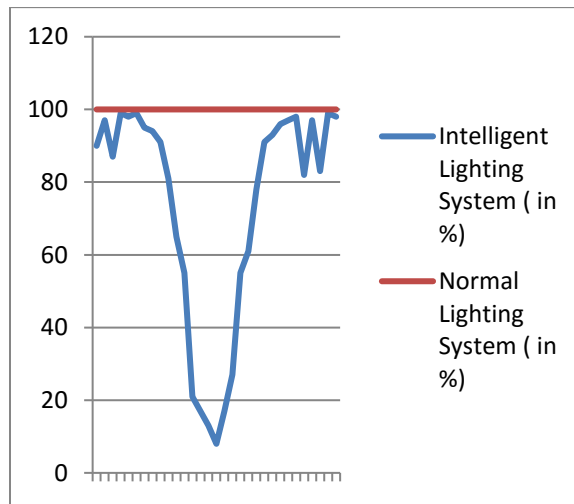


Fig 5: Comparison of power consumption by Intelligent and Normal lighting systems

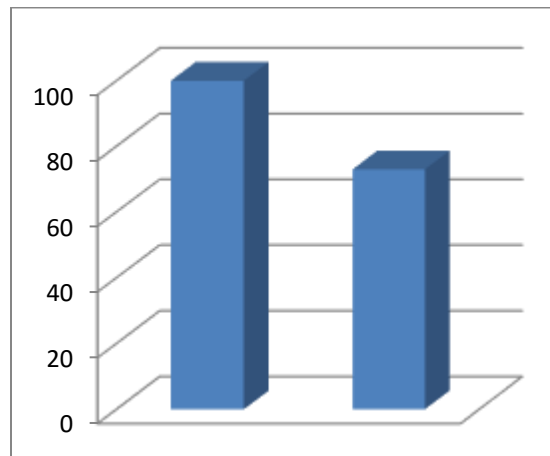


Fig 6: Power saving of Intelligent Lighting system.

consumed by Normal lighting system. Fig 6 shows average power consumed by Intelligent and Normal lighting system. In this way intelligent system is saving energy approximately 27% over normal lighting system.

CONCLUSION

These days saving energy is the most important factor, so many light control system have been launch in market. But due to some limitations and energy inefficiency, the existing light control systems cannot be successfully installed with energy efficiency and . Therefore in this paper we design an intelligent lighting system considering both, effective utilization of energy and user satisfaction. This intelligent lighting system controls LED light, utilizing motion and light sensors and uses Bluetooth wireless communication to operate lighting system as per user's need. This system automatically adjusts the minimum light intensity value to improve energy utilization. We have designed and implemented the intelligent lighting system in some testing conditions and found that this system reduces total power consumption in significant amount.

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