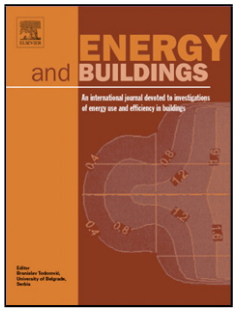

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Development Of A Prototype Smart Home Intelligent Lighting Control Architecture Using Sensors Onboard A Mobile Computing System

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Abstract

As smartphones become increasingly powerful and ubiquitous, integrating them into intelligent lighting systems can boost both convenience and energy efficiency. This paper presents an intelligent lighting system prototype with enhanced security features for smart homes. The custom-built Android mobile application made use of the onboard ambient light sensor to run a novel closed-loop feedback algorithm to implement daylight harvesting. A cost analysis shows that the whole system setup is slightly cheaper than commercial products and due to its daylight harvesting capabilities, has potential for monetary savings in the long run, outperforming current commercial products.

Keywords: Smart home, intelligent lighting, daylight harvesting, LED lighting system, mobile device, smartphone

1. Introduction

The Internet of Things (IoT) is an emerging concept of everyday objects that are interconnected with each other [1]. With this comes the concept of smart homes where consumer electronic products and systems are automated and can be controlled easily by the users improving convenience, comfort, efficiency and security [1]. Within the many subsystems of a smart home, lighting plays a profoundly big role in our daily lives, not just at night, but even during the day, where artificial lighting is used to light up the indoors. The uptake of light emitting diodes (LED) as the main light source in the residential segment is forecasted to be at almost 50% in 2016 and over 70% in 2020 by McKinsey [2], showing a high adoption rate of solid state LED lighting by consumers due to its high energy efficiency and long lifespan. With the advancement of LED technologies, much more technologically complicated and challenging controls can be performed on them compared to halogen bulbs or fluorescent lamps. As a result, improvements in the standards of living in terms of convenience, ambience, customizability and power savings by using artificial lighting can be achieved through an LED-based intelligent lighting system. For example, the brightness and color of the LED luminaires can be controlled, functionalities such as dimming can be enabled to save power or lighting color can be changed to suit the occasion, mood or situation. In a report released by the International Energy Agency in 2015, artificial lighting accounted for 15% of energy consumption in residential buildings [3]. Daylight harvesting which is a method in which daylight is used to offset the amount of electric energy needed to light up a space can save up to 27% [4] or even 40% [5] of lighting power in areas that receive a significant amount of daylight.

Seeing great potential in smart lighting, many industrial companies have taken up the challenge to create commercial products, such as Philips Hue, OSRAM Lightify, and LIFX. Though these are the leading smart lighting systems in the market, they are still lacking in many areas. For example, there is no closed-loop feedback control for the illuminance level of the room and hence daylight harvesting cannot be employed without the use of external sensors. Some other concerns associated with smart lights such as Philips Hue and smart homes in general which integrate with the IoT are the issues of security and privacy [6, 7]. The Philips Hue system along with some other smart home appliances were studied to show some security loopholes [6] and were even successfully hacked into [7]. This raises a huge concern as hackers are then able to monitor the status of these smart homes removing all privacy and would even be able to control the lights causing a blackout to the entire house, leaving the owner of the house worse off than using the traditional lighting systems with wall switches.

As the research on smart homes advances, various smart home models and architectures have been proposed. One such research constructed their own home server to automate various home equipment [8]. Some others proposed modifying residential gateways in smart homes for home energy management system [9] or to connect the smart home to the cloud [10, 11]. There are also various connectivity options for smart homes, and the wireless networks are usually preferred over wired solutions as the wiring has to be planned for during the design and construction of the building and therefore the smart home system would not be able to be implemented in older buildings unless extensive renovation works are carried out. Common wireless technologies used are Bluetooth, Wi-Fi and the most

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