ECE 445
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Senior Design

House Light Sensing System

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1 Introduction

1.1 Objective

It is very easy to accidentally leave a light on in the home when you are either going outside or going to sleep. Whenever this occurs, a person's electricity bill can rise by a large amount depending on the amount of lights that were kept on and their duration. Our goal is to allow for the user to see what lights are on in their home and to be able to control those lights remotely. We aim to solve this problem by using a board that contains LEDs and switches. The LEDs indicate what lights are on in the home, and the switches turn off the light. To monitor whether a light is on we will create a light sensing module which will be mounted in close proximity to the light source. To control the light we will make a relay module that can turn off the light source.

1.2 Background

The concept of monitoring what lights are on in the home and being able to turn them off remotely is not a new concept. Numerous different brands of smart lights are on the market and each one can be monitored and controlled wirelessly by the user. The problem with this solution is that the bulbs are very expensive; for example, the starter kit for the Philips Hue bulbs which contains 4 lights has a price of 200 dollars [1]. Very quickly buying these bulbs and making an entire house's light system 'smart' can cost a lot of money. Our solution will allow for the user to monitor and control their lights at a much cheaper price. Along with this unlike smart bulbs our system is not tied to the bulb so if the bulb dies then the user can just buy a cheap bulb to replace the dead one without having to worry about wireless monitoring and control.

The way that our project differs from the previous group is that they proposed a solution using a sensor via a door hanger to indicate whether a light is on or off by utilizing a pressure device and a z-wave light switch. This is different to our proposed design which is a modular based approach using light sensor units across the whole house that communicate via a WiFi signal to control what lights are activated on the LED board.

The advantage of using the original solution to the project is that the lights will be automatically turned off when a coat is no longer on a hanger, while our solution just indicates to the user that a light is on in their home and it is up to the user whether to turn off that specific light. The benefit of our design is that the user can decide if certain lights need to be on, for example if in the past the user wants to turn off their child's room light if they go outside this may not be desired if their child chooses to stay home as the child's light will turn off when the hanger is manipulated. Also if it is hot outside the user will most likely not need to use a coat so they need to manipulate the hanger in a way to turn off excess lights.

1.3 Physical Design

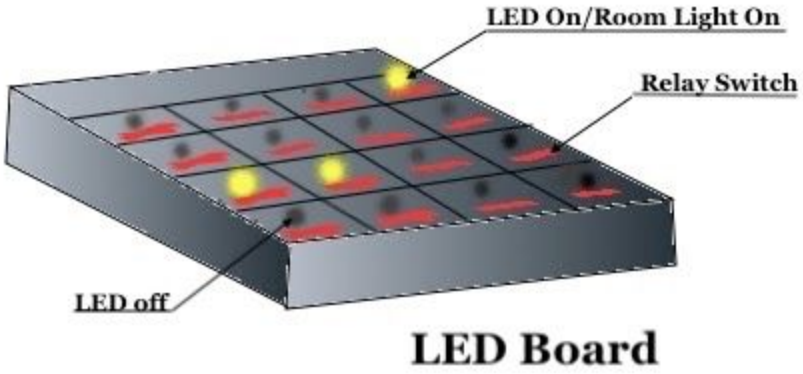


Fig. 1.3.1

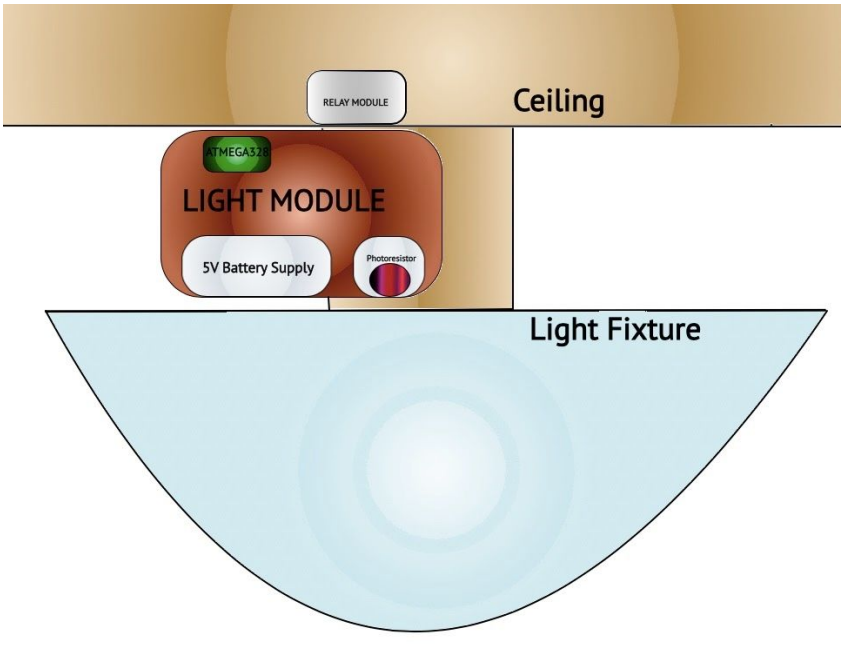


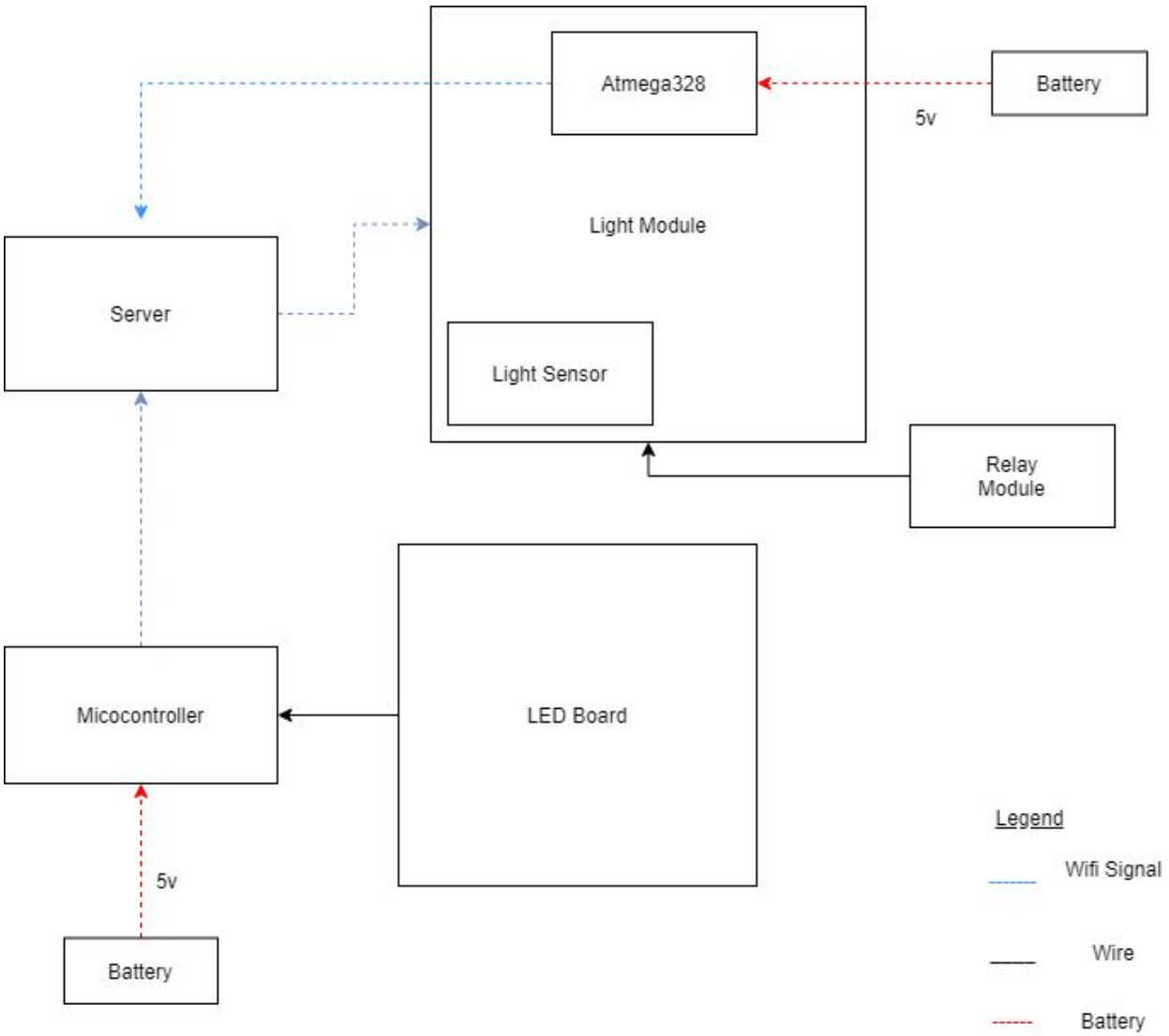
Fig. 1.3.2 Light Module

1.4 High-Level Requirements

- A Light Module signals a light is on only when the photoresistor detects light of intensity equal to or greater than the luminosity threshold determined from its main light source.
- The microcontroller must be able to interpret light sensor data wirelessly and turn the correct board LEDs on or off.
- The User must be able to turn off individual lights from the LED board.

2 Design

2.1 Block Diagram



2.2 Block Requirements & Functional Overview

2.2.1 Control Unit

The control unit is responsible for taking in data from each of the light sensors and then sending this data to the LED board to indicate what lights are on in the home. Along with this the control unit also takes in information from the LED board on what light the user wants to turn off and then sends this data to the relay which will turn off the light.

2.2.1.1 Web Server

The web server will take in input from the light sensors and will send this data to the LED board so that the corresponding LED will activate. The server will also take in input from the LED board if the board's switch is pressed. With this information the server will send this data to the corresponding relay module which will then turn off the light.

Requirement 1: If a light module detects a light source, the web server must contain this data..
Requirement 2: If any switch is activated on the LED board, the web server must contain this data.

2.2.2 Light Module

Light modules are responsible for determining the status of a light and communicating on/off light source data wirelessly to the server. Additionally, a module receives relay commands from the server and communicates those commands to the relay module.

2.2.2.1 Light Module

Each room's main light source will have its own light sensor module. Individual Light Modules consist of a wifi-module (Atmega328), and a light sensor (photoresistor). The modules will be powered using 5V portable batteries. The design must work for both day and night. Sunlight and natural light during the day should not affect the light sensors. In order to meet these conditions, a photoresistor will be used as part of the module. Using a photoresistor and placing the device close to the room's main light source will make sure only the luminosity from the light source will be high enough for the light sensor to detect.

Once powered the light sensor will be able to communicate data, whether the lights are on or off, to its microcontroller. The Atmega will then communicate this data to the server.

Each light module has a wired connection to its corresponding relay module. If the user requests a light to be shut off, the server will communicate this information to the correct light module. The light module then sends the appropriate signal to the relay.

Requirement 1: The photoresistor must be able to detect whether the light source is on/off during both day and night conditions.
Requirement 2: The light module must be able to communicate information from the server to its relay module.

2.2.3 Relay Module

The relay module is a relatively simple subsystem. This subsystem only contains a relay which will take in information from the web server. The way that the relay module takes in data from the server is from the light module which will have a wired connection to the relay module which contains information on if that particular light will be turned off.

2.2.3.1 Relay

The relay will be installed by the user to the light that they want to control. Once this is done then the relay will take in input from the web server. The only time that this occurs is if the user presses a switch on the LED board. When this occurs the relay will deactivate so that the light will shut off. This connection will output low if the user wants to turn off the light.

Requirement 1: The relay must be able to handle 120 Volts.
Requirement 2: When desired the relay must be able to switch the light on and off when activated.

2.2.4 LED Board

The Led board will have an led for each light in the house that a light module has been installed. As well as containing a switch that will enable the user to turn on or off a light in the house without physically going there. A microcontroller will be utilized in order to wirelessly communicate that a light must be turned on or off to a server.

Requirement 1: A wireless signal must be sent when the switch is activated or deactivated.
Requirement 2: The led and switches and microcontroller closest to the led board must be powered by a small portable battery that supplies 5 volts for the microcontroller.

2.3 Risk Analysis

The main risk of this design is that our wireless communication is an integral part in the functionality because it needs to successfully communicate back and forth from led board to server and then to each light sensor, and in reverse direction as well. Another section that might cause significant risk to our project is our installation of each light sensing module onto an existing bulb/lamp in the home. This area is a challenge because there is a possibility that if not careful we may short circuit a component and cause the existing light to be ruined.

3 Ethics and Safety

3.1 Ethics

Our design is in compliance with the IEEE Code of Ethics [2] and the ACM Code of Ethics and Professional Conduct [3]. To prevent any harm done to the user and the environment, as stated in ACM, code 1.2, and in IEEE code of Ethics, code 1, we will make our design process and the final product as sade as we can. Additionally we will strive to make the highest quality product that we can make which is in accordance with ACM code 2.1.

3.2 Safety

One issue that could occur would be if the LED board, light sensor module, or relay modules short. This would be a major issue since many of these devices handle high voltage and can potentially harm the user if they fail. For example if the light sensing module or the relay module short they could create a fire. As the number of sensors increases the potential for failure also will increase, so a major concern that we will work on is to make the modules as safe as possible so that this will not be a major issue. We will work on adding fuses wherever possible in the modules to avoid this problem.

The user is also responsible for installing the relay to their lighting fixture so there is an inherent danger where the user did not properly set up the relay module and this system may shock the user. Since the relay can control a 120 Volt device this shock can be deadly. For this reason the product should only be installed by people that have experience with installing electrical systems.

6 References

[1] “Philips HueWCA 9.5W A19 E26 4 set US BLE,” *Hue*. [Online]. Available: https://www2.meethue.com/en-us/p/hue-white-and-color-ambiance-starter-kit-e26/046677548544. [Accessed: 02-Apr-2020].

[2] “IEEE Code of Ethics,” *IEEE*, Jun-2019. [Online]. Available: https://www.ieee.org/about/corporate/governance/p7-8.html. [Accessed: 03-Feb-2020].

[3] “The Code affirms an obligation of computing professionals to use their skills for the benefit of society.,” *Code of Ethics*, 22-Jun-2018. [Online]. Available: https://www.acm.org/code-of-ethics. [Accessed: 03-Feb-2020].