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EMBEDED SYSTEM

Smart Lighting System Second Report

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1 Problem Statement

Nowadays, people leave their house without switching off the home appliances such as fans and lights due to busy life style. Such a careless behavior does not only result in wastage but also bring potential danger to the home. Owing to the above problems, an automated home control and monitoring system is needed to keep the wastage and danger to the very minimum.

Home automation has been a trend since the 1980's; with the introduction of networking, home automation has become much more practical. Smart lighting is a key component for upcoming traits in society. There exist many versions of smart lighting that come in various forms (e.g bulbs, hubs, switches).Existing smart lighting systems typically feature control from smartphones.

For this project, the team created a smart system for controlling home lighting. With conventional lights, it is not possible to control home lights from a distance. It is a challenge to control high voltage lights from a sensitive controller board. Lighting systems that learn the patterns for home lighting usage do not exist. A significant amount of energy is wasted when lights are left on in unoccupied rooms.

2 Requirement Analysis

Table I shows the functional requirements and constraints of the system. These characteristics are very general. Below, is a much more detailed explanation of the individual functional requirements and constraints.

TABLE I. FUNCTIONAL REQUIREMENTS AND CONSTRAINTS

Characteristics	F	C
Embedded Debian Linux platform		X
Motion sensor shutoff	X	
Controllable via Android application		X
Manual button and switch control		X
Recognize and utilize light usage patterns	X	
Controls home lights		X
System fits in 1 gang work wall electric box		X
Easy to use	X	
Configurable modes	X	
Communication, and sensors are optional		X
System is safe	X	

Functional Requirement (F), Constraint (C)

Embedded Debian Linux platform
The system is controlled by an embedded Debian Linux platform. The Debian Linux platform is programmed and wired to control all other subsystems of this project. The Debian Linux platform provides framework for communication with other subsystems.

Motion sensor shutoff
The system uses a motion sensor that can see motion in the room of the system's installation. If the motion sensor detects no movement in a room fora period of time, the lights in the room are turned off by the system.

Controllable via Android application
The system is controllable by an Android application. The Android application was developed by the team, and is only for communicating with the system. The Android application also has access to a record of all lighting and system control events.The feature for viewing and setting light changing events was not completed in this project.

Manual button and switch control
At all times, the system is able to be user controlled via manual buttons and switches. The buttons and switches are always visible to users. Control from the manual buttons and switches overrides any other control requests provided to the system.

Recognize and utilize light usage patterns
The system recognizes and utilizes light usage patterns. Any event of button, switch, or other

control requests is recorded with a timestamp. The status of the system and room lights is recorded in 15 minute intervals.The system records time and day of the week information in the pattern recognition. If desired by a user, the system can make suggested changes to the room lights based on the recognized light usage pattern.This feature was only completed and tested in simulation.

Controls home lights
Upon installation, the system is replacing an existing light switch. The lights controlled by this switch must be able to be controlled by the system.

System fits in work wall electric box
A one-gang work wall electric box is a standard home installment for placing light switches to control home lights. The system fits in a 1 gang work wall electric box, because this is the most common type of housing for home light switches. This feature was not in the scope of this project.

Easy to use
Using the system is intuitive. It is important that users are not frustrated when interfacing with the system.

Configurable modes
The system has configurable modes. The functionality of the system is not always the same. Users are able to configure the system according to their preferences. The various modes will be explained at greater depth in the “System State Diagram” portion of this proposal.

Communication and sensors are optional
The user is able to disable or enable: the Android application communication, and the motion sensor. These features may prove to be undesirable by some users, and therefore must be optional.

System is safe
After installation, the electrical components of the system should be not visible or touchable by users. It is important that no users are harmed when interacting with the system.This feature is out of scope for this project.

3 System Design Proposal

In our proposed model there are few components but the most important components are PIR, micro-controller, relay, opto coupler, The other components are very common like voltage regulator ICs like LM7805 is used to give micro-controller 5V constantly and LM7812 to give 12V constant supply to the relay as this ICs have high power dissipation capability, internal thermal over-load protection, and internal short circuit current limiting.

PIR which means Passive Infrared Sensor is a sensor that is used to sense motion within a range. It is also known as PID which stands for Passive Infrared Detector. Any motion of an object having a temperature above absolute zero is detected by PIR. PIR stands for Passive Infrared. Here the word passive is used for the reason that instead of emitting microwave energy the sensor is simply sensitive to the infrared energy emitted by the particle. Any object having a temperature above absolute zero radiates some energy in the form of infrared when it makes a move. PIR senses this infrared. The sensor is typically sensitive to a wavelength of 8-12 micrometer. Generally human skin having temperature approximately 93F- 99 F radiates infrared having wavelength 9-10 micrometer. Each model is having a particular range of detecting infrared.

If any motion is detected within the range the output pin becomes HIGH. As long as the sensor detects motion it is giving a pulse or signal which is causing to remain the light ON.

Figure 1 shows the general pin configuration of PIR model.

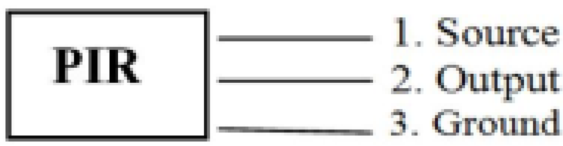


Fig. 1. Pin configuration of PIR

A complete block diagram of the proposed model is shown in Fig. 2. If the PIR detects a motion the output pin will be HIGH. The signal from the PIR is very small and we need to amplify this signal for further procedure .An op-amp is used to amplify the signal from PIR. The amplified signal will be an input for the microcontroller. When the input pin of the microcontroller receives a signal the output pin will energize the relay to make the light on. In the block diagram we are using the term load to indicate any electric load we are expecting to control with PIR. 5V DC voltage is needed to make the microcontroller ON.12V DC voltage is needed to make the relay ON.

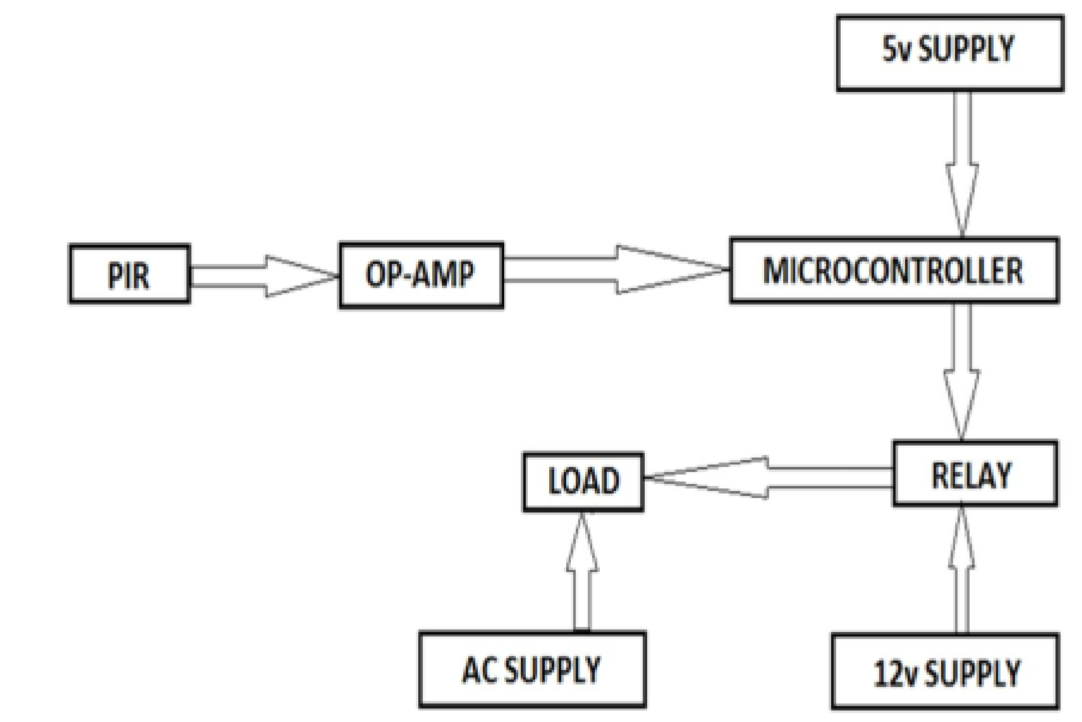
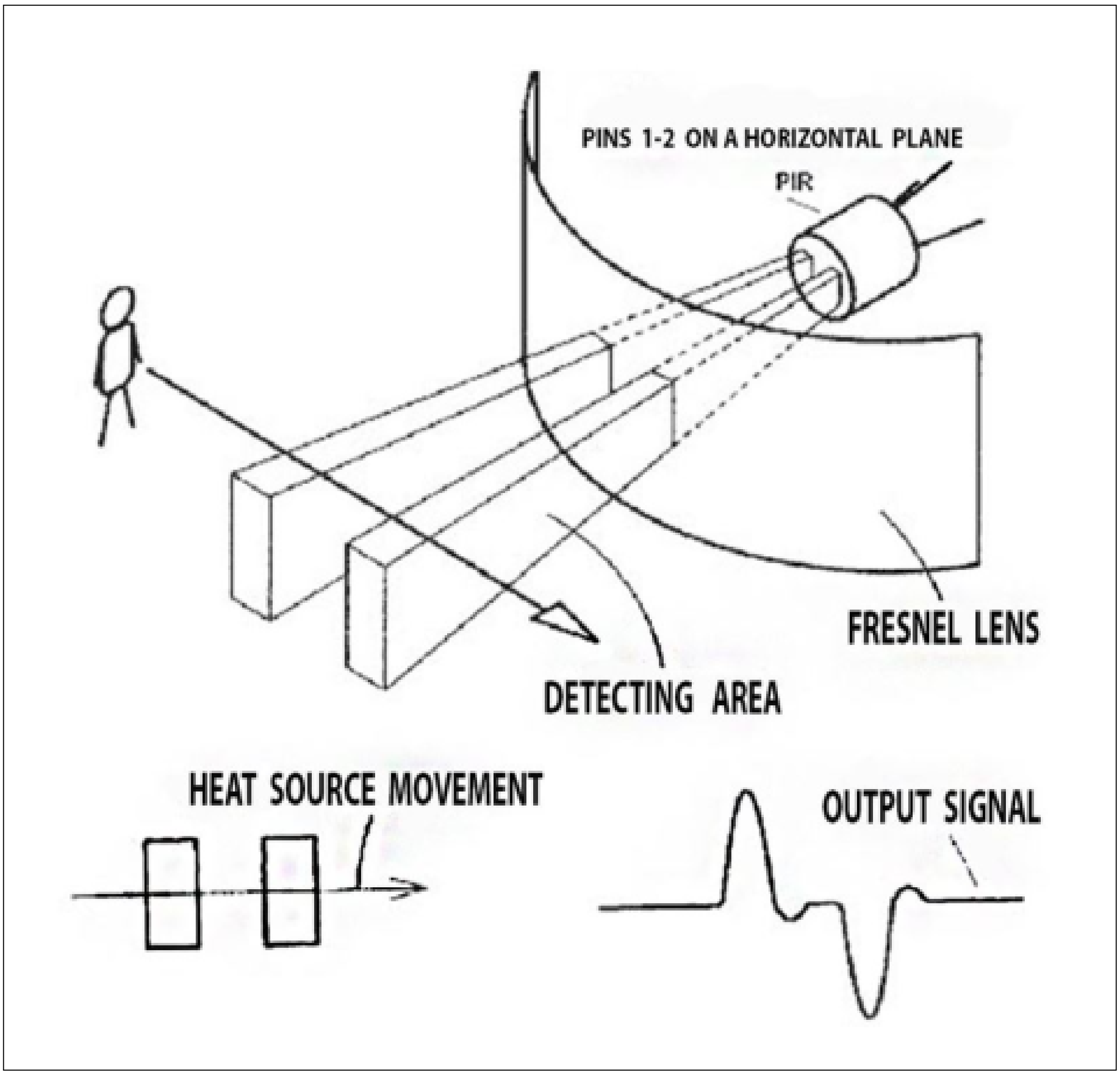


Fig. 2. Block diagram of the proposed model

PIR works on getting any pulse by moving in front of it. x'Especially human movement is detected quite well. But every PIR sensors has its definite range. It works only within the ranges. So choosing a PIR is very important thing in this project. As PIR has range in angles we have to calculate the angles where it works properly. PIR sensors working principle is shown below by the figure 3.

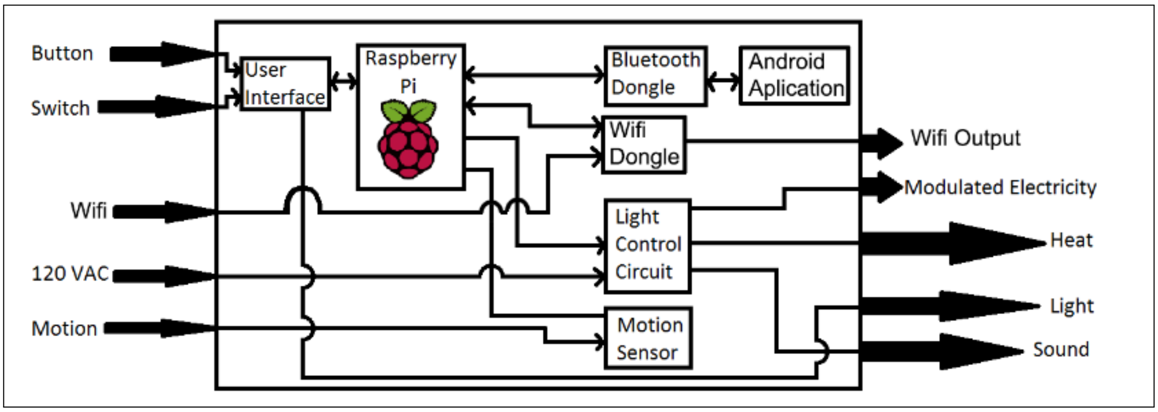


4 Implementation Method

4.1 Method A

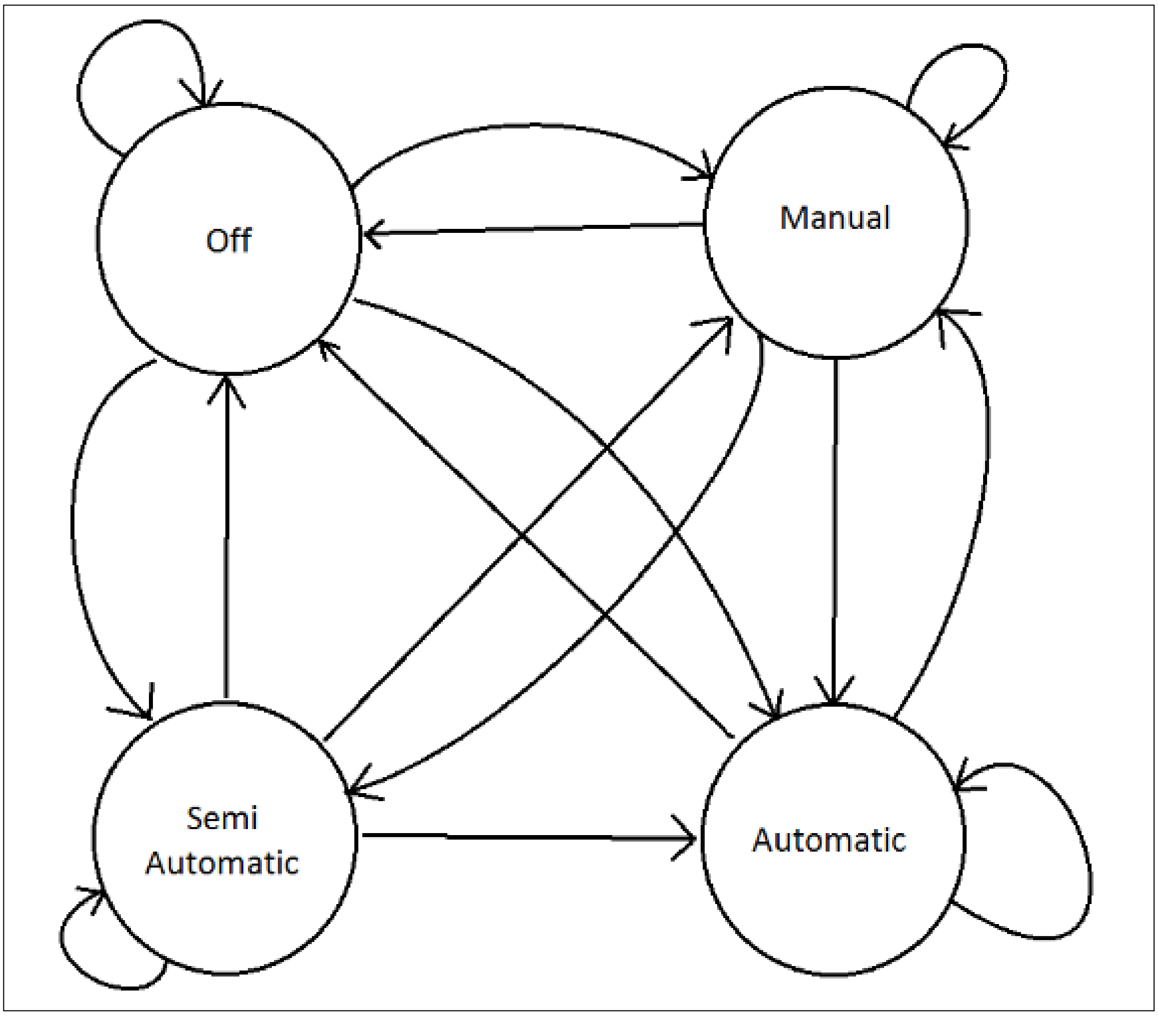
The system is a smart light switch that can replace ordinary light switches to control typical lights. The electronics are protected from outside damage. Users control the system via four buttons and a switch on the panel of the system or through their smartphones over Bluetooth or Internet.An application for Android phones was developed for user interface.

4.1.1 System Block Diagram



Above figure shows the system glass box. The Raspberry Pi handles all of the main communication and control of the system. The user interface is a set of buttons and switches for manual control of the system. The Bluetooth and Wi-Fi dongles are connected to the Raspberry Pi USB ports for wireless communication. The motion sensor is connected to the Raspberry Pi's GPIO pins. The light control circuit handles the high voltage light control.The light control circuit is needed to manage the high voltage of typical lights, without breaking the sensitive Raspberry Pi board.It is important to isolate high voltage home lights from the reset of the system to avoid failure.The user interface is a panel in which users control the system manually. The user interface panel consists of various buttons and switches that are for control, and toggling various functionalities such as Bluetooth communication and motion sensor control.

4.1.2 State Diagram



In this document, the words state and mode are used interchangeably. Above figure shows the fours states of the system. In the off state, lights are always off. In the Manual state, the lights only change as requested. In the semi-automatic state, the system makes recommended changes to the light based off of the recognized pattern, and information from the motion sensor. In the automatic state, the system controls lights to mimic those lights usual usage.A user can change between the four states at anytime through the Android application(granted the option is enabled), or via four buttons shown on the panel. The buttons on the user interface panel have indicator LEDs to let the user know what state the system is in.

Off: In this state the lights are off, and any request to turn the lights on are denied. The user may change to any other mode from the manual buttons, or Bluetooth(granted that it is enabled). The system records when a user attempts to change the light status, or if the mode is changed.

Manual: The system makes no changes to the light status, unless specified to do so by the user in real time. Control may be through manual control, or smartphone (if enabled). The system records when any changes are made to the lights, or if the mode is changed.

Semi-Automatic: The system toggles the light status based on patterns recognized, user preset times, or the motion sensor observations (if enabled). If no motion is detected for 30 minutes, the lights are turned off. The user may change the status of the lights from their smartphone or with the manual controls. The system records when any changes are made to the lights, or if the mode is changed.

Automatic: All light status toggle requests are denied. The system uses recognized patterns to automatically turn lights on or off at typical times, so that it seems as if someone is home. The mode changing rules as explained in the aforementioned modes, still applies.

4.1.3 Discussion

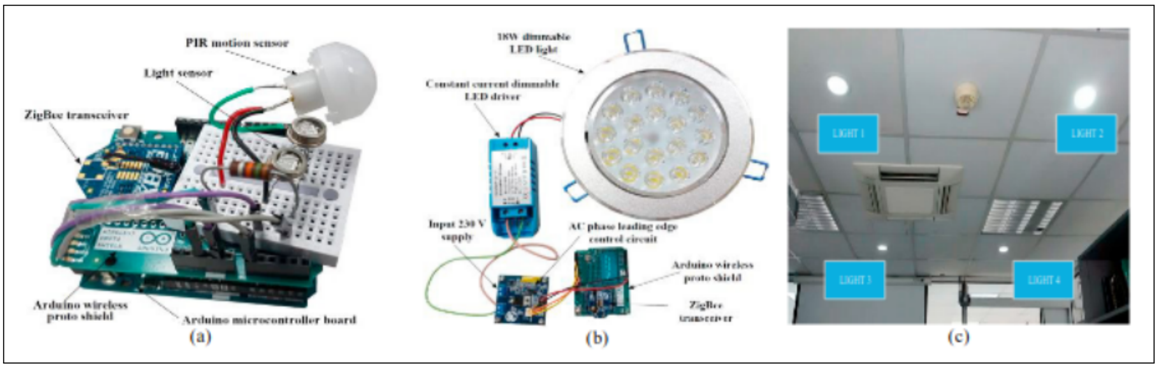
This project is a smart light switch with smartphone control over Bluetooth and internet. The system recognizes light usage patterns, and can make predictive changes to the lights based off of these patterns.

The system's main controller and computer is a Linux embedded system. There is a motion sensor, Bluetooth USB dongle, and Wi-Fi USB dongle for smarter control. Wi-Fi, and Bluetooth control may be disabled with switches. The motion sensor may also be disabled with a switch. The system records every change made by users. Modes are always interchangeable. The system must fit into a 22-cu 1-gang new work wall electrical box. Based off of Predicting user behavior using transition probability, the system recognizes light usage patterns, and uses those patterns to work with the user.

4.2 Method B

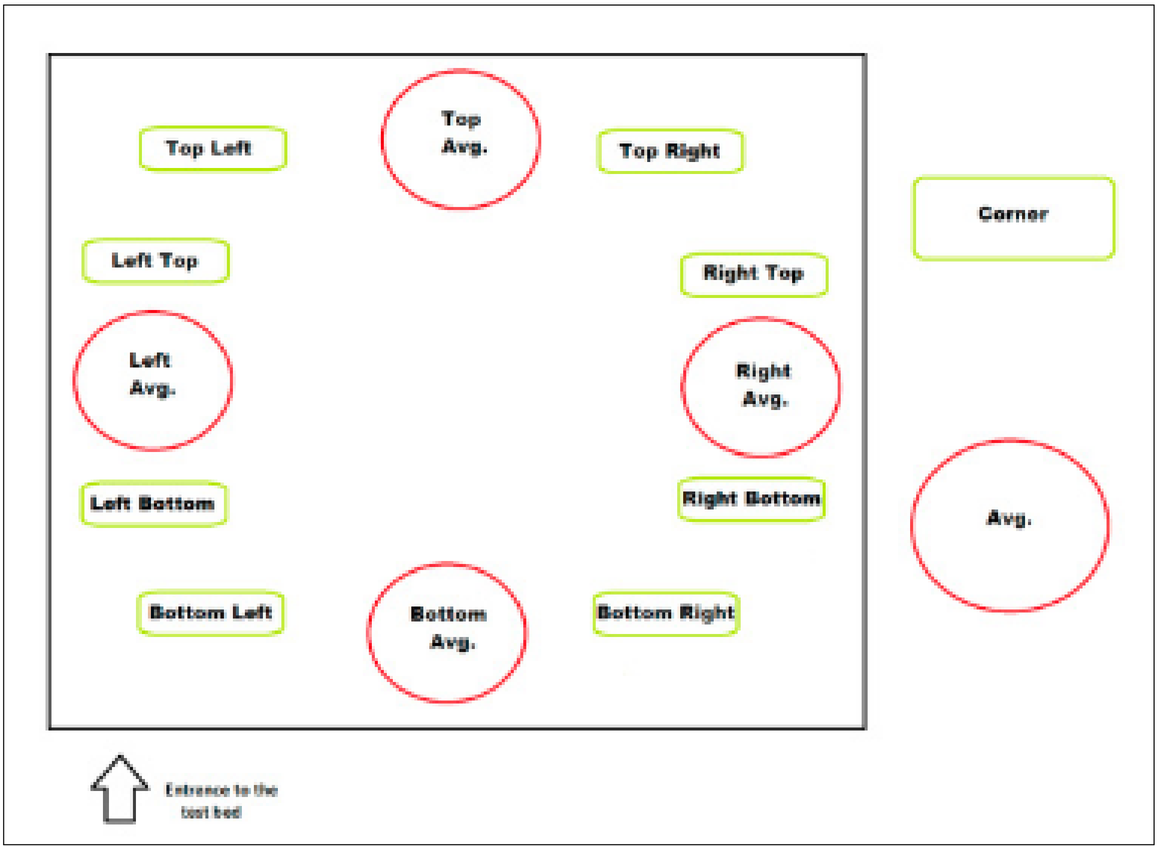
4.2.1 Description

A test-bed is being developed and smart lighting system is extensively being tested. The test bed consists of means to vary the room luminance. The illumination levels can be set by the user with the help of sliders on the smart App on a mobile phone or desktop, and can be controlled for the individual user based on his or her position.



The test-bed consists of a voltage controlled SrCoO2 film, which can be electronically controlled to limit or vary the amount of natural daylight entering the room. There is also a remote controlled roller blind available which when switched ON can reduce the room illuminance by 50%.

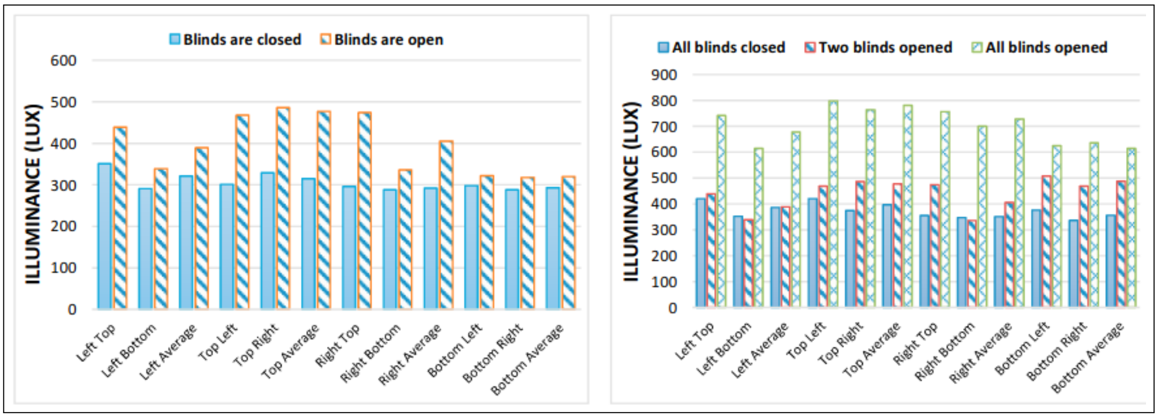
Finally, there is also a manually controlled blind to change the luminance of the room. The Figure shows the components of a sensor node and it shows an actuator node with all their components, respectively. Actuator node varies the LED brightness based on the sensor nodes' output signal and the signal received from the coordinator. The coordinator runs a control algorithm and maintains the room luminance to the set point. The test-bed is shown in the above Figure.



The above figure shows the spatial representation of the test bed, while the figure shows the two test bed scenarios with smart glass transparent, pull cord blinds and roller blinds. The test bed has four primary lights, which are supplemented with the LED lights of the smart lighting system. The recommended lighting requirement for a meeting room is between 300 to 750 lux. It also illustrates the lux values at eight corners of the test bed with all three blinds closed and all three blinds open when the smart lighting system is not activated. It can be noticed that the room luminance is less than the recommended value, when all the three blinds are closed.

The left picture shows a complete testing system with smart glass transparent, pull cord blinds and roller blinds completely up; while the right one illustrate a complete testing system with smart glass translucent, pull cord blinds and roller blinds completely lowered down.

4.2.2 Discussion



When the smart lighting system is activated, it can be noticed that there is a considerable improvement in the room luminance. In this case, the lux value lies within the recommended range of luminance at all the eight corners of the test bed. The above Figure illustrates this improved luminance in lux.

the Implementation of Smart LED Lighting and Efficient Data Management System for Smart Buildings without compromising the visual comfort of occupants. The proposed lighting system used ZigBee and Wi-Fi communication to control the lights of commercial/residential buildings according to natural available daylight, occupancy or as per the requirements of the inhabitants of the building. The lighting system can be operated in three different modes: Manual, Auto, and Hybrid to account for various applications. A wireless sensor and actuator network (WSAN) is used to collect available data, regarding the usage of personalised smart LED lights by occupants in the building. The paper also presented the detailed test-bed implementation of the proposed smart lighting technique and data management system to illustrate the impact of the proposed lighting system on energy consumption and occupants' visual satisfaction. The results show that when the proposed lighting system is applied, the lux values lies within the recommended range of luminance in the entire the test bed. In future, we plan to enhance the capabilities of the proposed system in terms of self-learning of user preferences and accuracy.

5 References

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