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DESIGN OF A SIMULATED AUTOMATED LIGHTING SAVING SYSTEM

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ABSTRACT
The management and conservation of power consumed through lightings could prove advantageous in modern day higher institutions of learning. Studies provided challenges of not considering the former which were payment of high energy bills despite little usage, over illumination among others. In order to control energy wastage, survey has it that different technologies are geared towards minimization of energy consumption such as daylight harvesting, occupancy sensing and personal control among others. In this paper, a prototype of light control system has been designed, fabricated and tested for stability. It consists of a Passive Infrared motion sensor, light dependent resistor with a capacitor, Raspberry Pi 2 model B interfaced with a breadboard, system software and lighting loads operated by a relay. Passive Infrared motion sensor (PIR) was used for motion detection while the entire system is controlled by the Raspberry PI 2. The designed system eases the task of controlling light by ensuring that, when it is dark and motion is detected in the motion sensor's coverage area, the light is switched ON automatically, when no motion is detected and the motion sensor detects no obstacle in its field of view, the light is switched OFF after a period of time. However, when it is not dark, the system does not respond to the motion detected by the motion sensor, hence, avoiding energy wastage. The designed system is programmable, automated, and portable and proved to be cost effective.

Keywords
Automated, Lighting, Passive Infra Red, Microprocessor, Sensor, Light Control Systems.

1. INTRODUCTION
Power as a resource for energy is of immense benefit to mankind and currently, there is over dependence of the world's population on the supply of power. The over reliance of this resource continues to increase up to a point whereby some studies have identified the increase in its use as a vital component of emerging economies [1][2].

The demand for power has reached a point where the level of its consumption has become an index used in measuring the level of development of countries across the globe, but despite these appeal, it has remained one of the most wasted and ill-managed resource [3]. Studies have also shown that a lot of factors may have accounted for the deliberate waste of power such as poor energy conservation policy [4], lack of public awareness of the need for efficient utilization of power [5], and the nature of manually controlling appliances which leads to power wastage [6]. With regards to the latter, the management and conservation of power is very vital to economic growth because of the growing concerns for fast depletion of other non-renewable sources of power [7].

Lightings form an essential output of what power provides. Lightings in homes consume eight to fifteen percent of an average household electricity budget, and household energy savings is achieved through an efficient and well-designed lighting [8]. The obvious problem in many developing countries is that lighting energy is wasted in buildings because of poor planning which make buildings over-illuminated or under-illuminated considering the limited amount of power generated and transmitted [9]. In Nigeria, power generated on average is mostly less than 3000 mega watts, but until recently in 2017 up to 5000 meg watts and shared by over 150 million populations among domestic, industrial and general needs. However, still, lightings have not been properly managed, controlled, and conserved.

The focus of this paper is on lightings in academic colleges and universities where the orientation and awareness is believed by the authors to be kick started, especially in developing countries such as Nigeria. The reason is the constant use of lightings day in day out, in halls of residence, university classrooms, academic offices and the related. The purpose of this paper is to design a prototype of an automated lightings saving system for utilization in University halls of residence using raspberry pi technology.

2.0. MANAGING LIGHTINGS IN COLLEGES AND UNIVERSITIES

Study has it that the consumption of lighting is greater than 2000 terawatt-hours of electricity globally [10]. In times past, the Colleges and Universities in the United States and Canada spent an average of 1.10 dollars per square foot on lightings; which attributed 31% of their total energy utilization [11]. However, they have witnessed improved management and control by their use of automated power saving systems. In developing countries such as Nigeria, there is already a persistent power problem caused by lack of proper planning for lightings, and in a situation whereby the consumption of limited power available for provision is on the decline; students keep the lights and fans on in their rooms almost throughout the day, the lights in the hallways, staircases, and restrooms stay on at all time. Most times, the people responsible for replacement are reluctant or negligent, hence, leaving some of these places over illuminated.

Investigation into a typical example of a fast growing University in Nigeria, Afe Babalola University Ado-Ekiti (ABUAD), revealed that an average of eight million naira (N 8 000 000) and twenty-eight million naira (N 28 000 000) is spent on energy consumption and power plants respectively. One major consequence of the above is that as the university is still expanding, the cost spent on power will perpetually be on the rise despite the use of alternative sources of power supply. It was observed that lightings amounted for more than 80% of what is consumed in the university. In the case of Asian universities, the situation is changing and universities have had to adjust its energy use habits in order to cope with the current situation of inadequacy of supply as well as rising costs, and have greatly minimized waste of lightings by the use of peak demand-reducing strategies without any increase in energy supply [12]. [13] Described six most common strategies used in advanced lighting control to reduce electricity consumption which are: daylight harvesting; occupancy sensing; personal control; time scheduling; task tuning; and variable load control. Other lighting control strategies are event management, automated maintenance, and demand response. Consequently, all these findings have since

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made it imperative for the design of automated lighting saving system.

Related Works on Light Control Designs

Some related works reviewed as shown in table 1 shows the various types of light control designs. They are Detector based control systems, Microprocessor based systems, Microcontroller and single board based systems and PIC.

The system utilized the Raspberry Pi technology, motion sensors and a photo resistor to actualize the aim of this paper. Fritzing, a software tool that helps users document and share prototypes and also to layout, teach and manufacture printed circuit boards (PCB) is used to depict the breadboard and schematic view of the interconnections of the system devices. A proper analysis of existing literatures and appropriate steps of system development of the system coupled with the devices were selected and the system was developed.

The choice for the technologies were: Raspberry Pi-because of its speed and capacity to run on multiple programs; Passive Infra Red (PIR) and LDR Sensors-because of their potentials in energy saving as compare to others. The choices were combined in order to achieve lighting energy savings of 38% [14]. This is the reason for the choice made for this paper, the block diagram in figure 1 and 2 above show these devices and the interconnection between them.

Table 1. Related work based on technologies used

Authors	Tool Used	Category	Description
[15]	Light sensor, wireless networks, sensors and actuators	Detector Based	A lighting optimization approach for open capable of tuning lighting to each occupant's preference
[16]	Dimming controller (analog/digital0, toggle watches	Microprocessor Based	Uses analog and digital interfaces to control dimming ballasts through traditional toggle switches
[17]	Passive Infra Red (PIR) sensor, Microprocessor, radio	Microcontroller Based	Designed for light intensity detection and control using both microprocessor and light sensors.
[18]	Terminal control, wake-up function, timers	Detector Based	A street smart controller with dual functions which includes time and photo-electric controls
[3]	PIC16F84 microcontroller, PIR sensor	Microcontroller based and single board based systems	Automatic light control designed to save the usage of electrical energy
[19]	Arduino, PIR Sensor, Daylight resistor, server, timers, wireless technology	Microcontroller based and single board based systems	A proposed system with multiple sensors as PIR, daylight sensors and wireless technology in order to control LED light according to user state and outside light
[20]	Rasberry Pi, camera module and Buzzer	Microcontroller based and single board based systems	A smart lighting system using a Rasberry pi in a lecture room. It was implemented to carry out surveillance during examinations and buzzer to indicate end of periods.

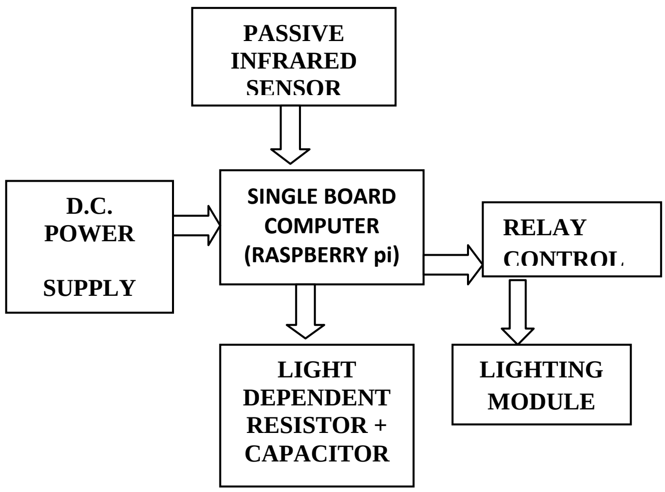

Figure 1Block Diagram of the system (Adapted from [3]

Algorithm for the System

The algorithm below was coded and implemented for the operations of the raspberry pi.

i)Start program

ii)Manual switch: while manual switch is on, go to step (iii), if not go to step (ix)

iii)Check PIR sensor state: PIR sensor is ready.

iv)If environment is dark go to step (v), if not let lighting remain OFF and go to step (vii).

v)Check if PIR is HIGH: if PIR detects motion, go to step (vi). If not, go to step (vii)

vi)Switch lighting ON

vii)Check PIR sensor state: PIR sensor is ready.

viii)Go to step (iv)

ix)End program

Code Development

The program code was written as a Python file (.py) or (.pyw), using the Python IDLE on the single board computer, Raspberry Pi 2. Python is a comprehensive and flexible editor for design and development of all many application programs and embedded systems. The program can also be run on the command line environment of the Raspberry Pi 2. The code does not need to be compiled and/or burned into any memory like other microcontrollers because it has a Graphical User interface.

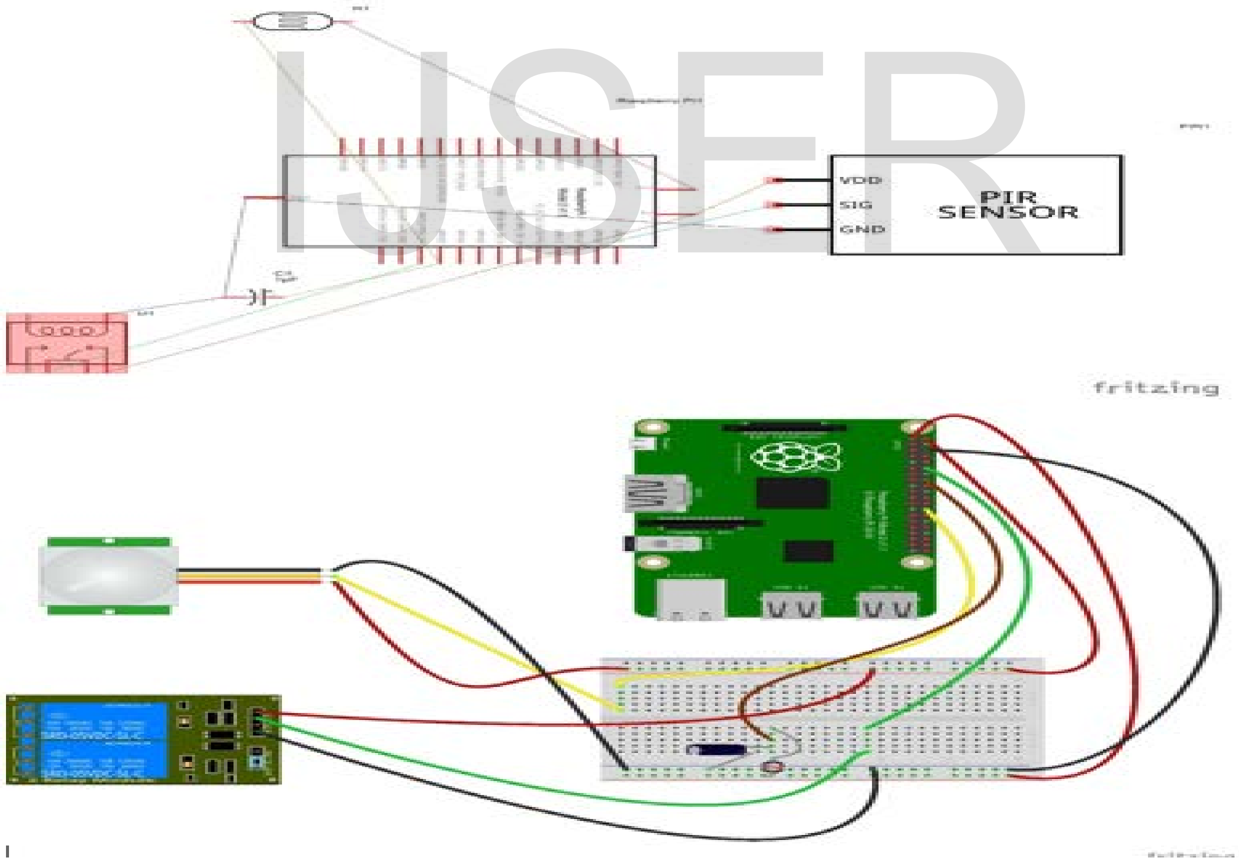

Figure 2. Breadboard view and Schematic of the system

4.0 IMPLEMENTATION AND TESTING

System Response to Motion Detected by PIR Sensor

The program was used to write the program code that detects the movement of a person is run on the Raspberry Pi interface using either the python IDLE or the command line interface of the Raspberry Pi, the PIR sensor requires an initial stabilization of about 10 to 60 seconds which is necessarily allowed for it to familiarize with the surrounding environment [21].

Once the PIR sensor detects the movement of a person in its vicinity, a high is sent to the signal pin, the program prints out some text; "Motion Detected!" and when the person leaves the vicinity of the PIR sensor, the program prints "Ready!" waiting for the next movement. Here the program is pretty simple, the Raspberry Pi GPIO pin 7 is used as input; it can detect when the PIR module detects motion. The pin will continually check for changes, so a while loop is used. This is an infinite loop so the program will run continuously unless it is stopped manually.

Test with Mains Electricity

The system is tested using a light bulb connected to the mains electricity via a relay connected to the Raspberry Pi GPIO pin 18. When the PIR sensor detects movement lights go on if the person moves away from the sensor's field of view, the lights remain on for some time and then goes off.

System Response to Motion Detected by PIR Sensor and Light Dependent Resistor

The LDR sensor is another piece of equipment in the prototype circuit and without it we wouldn't be able to detect whether it is dark or there's light. In the daylight the sensor will have a resistance of only a few hundred ohms whilst in the dark, it can have a resistance of several mega ohms. When the capacitor measures the resistance of the LDR sensor, the measurement provides the difference between when it is dark or not.

By adding the LDR to the prototype, the program code has some conditions added to the detection of movement before the light bulb can be turned or remain in an off state. These conditions however are set to control the use of lightings at different times of the day. The ensuing states are described below provided the manual switch if the light bulb is on:

i. **The PIR sensor detects movement and there's substantial amount of daylight**: when the program code is run, the light bulb connected to the circuit remains off because, no signal is sent to the Raspberry Pi GPIO pin 8 which controls the Relay. The program is an infinite loop, it will continue in this state until the program is stopped manually.

ii. **The PIR sensor detects no movement and there's substantial amount of daylight:** the light bulb remains off in this state. No signal goes to the Raspberry Pi pin 7 and pin 8 for the relay PIR sensor respectively and the daylight does not prompt the turning of the light bulb, so the condition for turning on the light bulb is not satisfied.

The test is carried out on the prototype by demonstrating no human presence detected by the PIR in a dark environment or the LDR sensor is covered by a finger or an object indicating darkness.

iii. **The PIR sensor detects movement and there's darkness or reduced daylight:** the light bulb comes on in this state. A signal goes to the Raspberry Pi GPIO pin 8 which turns on the light bulb. This is because the condition in the program code is required to turn on the light when it is considerably dark according to user preference and movement is detected.

The test is carried out on the prototype by demonstrating the presence detected by the PIR sensor in a dark environment or the LDR sensor is covered by a finger or an object indicating darkness.

iv. The PIR sensor detects no movement and there's darkness or reduced daylight: the light bulb remains off in this state. No signal goes to the Raspberry Pi pin 7 and pin 8 for the relay PIR sensor respectively even when it is dark, so the condition for turning on the light bulb is not satisfied.

The test is carried out on the prototype by demonstrating a person's presence detected by the PIR sensor, figures 3 and 4 below shows the program code window running and the prototype responding to user actions.

Power Supply

The Raspberry Pi is powered by the small micro-USB connector found on the lower left side of the circuit board. This connector is the same as found on the majority of smartphones and some tablet devices. Many chargers designed for smart phones will work with the Raspberry Pi, but not all. The Raspberry Pi is more power-hungry than most micro-USB devices, and requires up to 700mA in order to operate. Some only supply up to 500mA, causing intermittent problems in the Raspberry pi's operations.

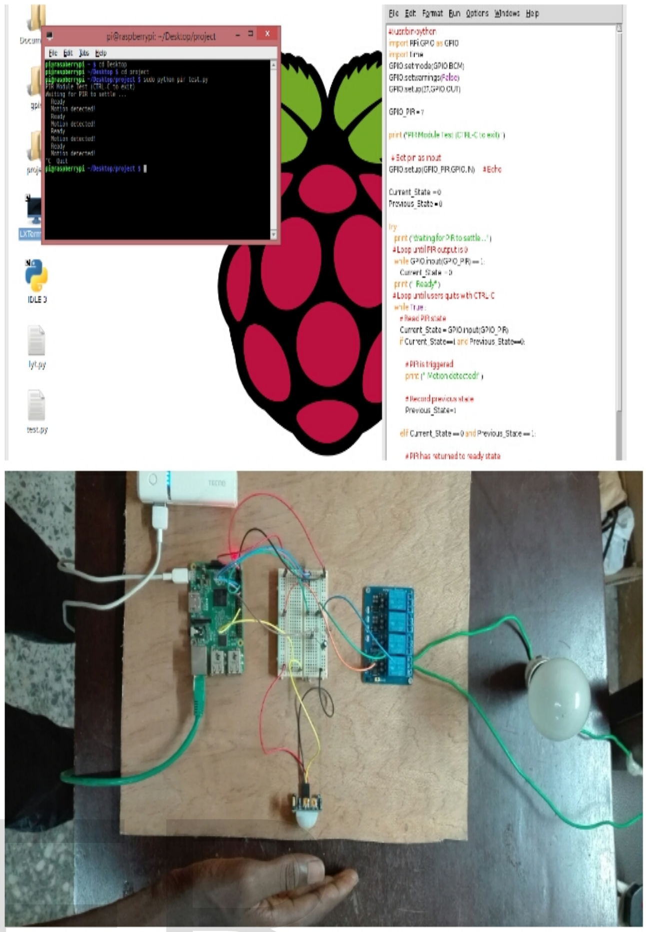

Figure 3.PIR sensor detects movement without use of the light bulb during day time.

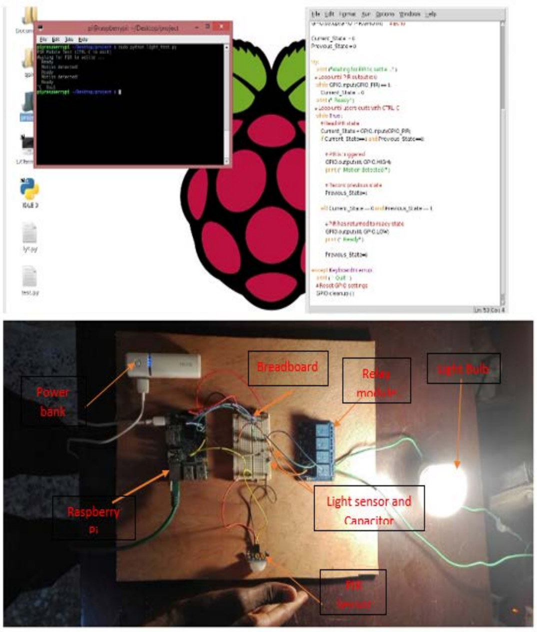

Figure 4. Program code window on Raspberry pi and prototype during testing

5.0 Conclusion and Recommendations

Conclusion

The designed system acquired two inputs from the motion sensor (PIR) and light sensor (LDR). They are based on the code stored on the single board computer (Raspberry Pi) automatically controlled by the light bulb (load) via the relay. The light bulb remains off when there is daylight, when there is darkness and there is no movement and when there is daylight and movement. Otherwise, it stays on for the period in which the motion sensor detects movement. The time delay after which can be set by the user and the system is allowed to make the choice.

This paper was driven based on an implementation of this system in Nigerian University Halls of residence. Also, in this project, energy consumption was investigated in developed and developing countries and in Universities in Nigeria. Strategies to control and increase energy performance were reviewed from which the choice of control strategies were chosen for this paper. The system was tested and it proved to be reliable, compact and portable, hence, it can be employed in university halls of residence in Nigeria for energy control/management operations to help limit electric energy consumption and wastage.

Recommendations for Future Work

Though the designed system was able to reduce energy wastage from lightings, a few developments can be made on it to make it more robust. These include;

1. Extending the system to include rooms with multiple exits/entrances by employing several sensors. This arrangement would require installation of multiple pairs of transmitter-receiver sensors and a logical combination of the outputs. In addition motion detectors with a higher resolution can be integrated in the system to improve on the system robustness. This can be achieved by using detectors with a wider field of view and longer detection distance. This would be suitable for multiple door access and higher detection rates of occupants to evolve a more reliable system.

2. The designed system can also be configured in such a way that the duration of time for which the lights remain on/off within a 24 hour period is recorded and use the recorded data to estimate energy usage and also for planning actions. This can be achieved by using data loggers or employing timer registers and modifying the program code.

3. In order to count the number of persons accessing a controlled room, a person counter circuit comprising a pair of infrared transmitter and receiver can be used. This can be arranged in a manner that for a person to enter the controlled room, both sets of sensors must be cut subsequently. If the first pair of sensors is traversed followed by the second pair, the counter is incremented indicating that someone has entered the room under surveillance and the count is recorded. On the contrary, when second pair is traversed followed by first pair, the status of the counter is decremented by one and this is also shown and recorded.

4. The system can also be expanded to include a surveillance camera that records in real time, motion that is detected thereby turning on the light.

5. This system should not only just control lights but all electrical appliances that needs to be controlled, therefore this system can then be increased to include any electrical appliance that doesn't require constant use or does not require use when persons are not in the room to conserve energy.

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