CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

Sensors have played its role in the use of our everyday objects such as touch-sensitive elevator buttons (tactile sensor), lamps that brighten or dim by touching the base (Hosseinioun, Al-Osman & El Saddik, 2015). Besides various countless applications of which most people are never aware and with advances in micro-machinery and easy-to-use microcontroller platforms, the uses of sensors have advanced and so far, expanded beyond the traditional measurement methods and brought them all towards the verge of extinction. Many others diverse kinds of sensors like motion, humidity, moisture, light and even sound sensors has also come into the sensor "field-of-play" and the existence and evolution of sensors combined with the fast-rising technology of artificial intelligence (AI) has over time, rapidly taken away the need for unnecessary human measurement and calculations.

The term "Internet of Things" originated from Kevin Ashton around the year 1999 mentioned first during his presentation speech on the launching event of Auto-ID Labs, founded by himself, David Brock and Sanjay Sarma (Auto-ID 2013). Ever since, IoT became a regular term in major sectors like transportation, agriculture, industrialization, health-care and even in the communication sector as a major. Because of the rapid emergence of IoT in the computer technology world, the word "thing" in the concept of Internet of Things is an entity, an object or any possible item that communicates directly or indirectly in the real-world network. IoT is generally seen as normal network devices being able to sense, detect and gather various data from every source they can, and that data is then shared across the Internet where it can further be processed and integrated into other forms of use.

Although Internet of Things seemed to have evolved with growing technology, its major motive has remained unchanged and that is enabling computer detect and sense information without the aid of human intervention. IoT consists chiefly of PC-based machines or equipment communicating and initiated into other different machines or computer devices, even objects and environmental infrastructures. Often times Internet capabilities are being integrated into the conventional electrical appliances to make them function as IoT devices. This also proves that the Internet is the most popular means of communication, fastest and safest above all of its other attributes.

IoT technology has so far evolved as decades of technological evolution passed and has birthed development and support from several other technologies like Radio Frequency IDentification (RFID) Technology, Wireless Sensor Network (WSN) Technology, Cloud Computing, Networking Technologies (e.g. 3G, 4G, Bluetooth, Wi-Fi, etc.), Nano-Technology, Micro-Electro-Mechanical Systems (MEMS) Technologies and Optical Technologies above all others (Al-Fuqaha, Guizani, Mohammadi, Aledhari, & Ayyash, 2015).

IoT technology has also given rise to remote automation technologies in which this project work is rooted on. And with support with technology-driven setups from Arduino, an open source technology that integrates with other nano-equipments consisting of diverse modules that possess various advanced functionalities (Madakam, Ramaswamy & Tripathi, 2015).

Some of these equipments and modules include various sensor modules (light sensors, proximity sensors, distance sensors, temperature sensors, moisture sensors, etc.), display modules (LED display, LCD display, matrix, etc.), communication modules (Serial COM, Serial Ethernet Bridge, Serial Ethernet Client, etc.), audio module (e.g. buzzer), SD card module and many others. This project is set to design and implement a proximity sensor-controlled switch with the use of Internet of Things (IoT) Technology.

1.2 Statement of the Problem

Ever since electrification began, electrical devices were switched by connecting them to or disconnecting them from the power grid (Twumasi, Dotche, Banuenumah & Sekyere, 2017). Technology began to make waves decades after and with time physically disconnecting a device from its power/energy source gradually became old-school. In these present years of technological advancements, switching has been done electronically (automatically).

This means that the inner circuit of the device itself is disconnected from the switching circuit. As a result of this, the device could be powered on or off by a remote control or in the case of this project work by an automated switching panel controlled by movement detected by a proximity sensor. Some computer main boards even allowed reaction to power network events. However, the downside to this record-breaking invention is that the switching unit kept consuming electrical power/energy as long as it stayed on (Adetiba, et al., 2011).

This project was hereby focused on making the electrical device toggle on or off with varying motion within the specified area, hence controlling the misuse of electrical appliances in the class, preventing power wastage and conserving electrical energy. Thus, this project work focused on solving the following problems:

i. **Misuse of Electrical Appliances:** It was discovered that individuals were prone to misuse electrical appliances especially in organized structures like academic environments where students and members of staff forget to turn off electrical appliances when not in use by them.
ii. **Excessive Drainage of Electrical Power:** The above stated problem then caused the wastage of electrical energy meant for preservation due to the misuse and abuse of electrical appliances.

1.3 Aim and Objectives of the Study

Aim

The aim of this project was to design and implement a proximity sensor-controlled switch using Internet of Things (IoT) Technology.

Objectives

The objectives of this project were listed below as follows:

i. Designing a motion-controlled switch to detect the movement of a person(s) and objects within a specified area.
ii. To automate the control of various electrical appliances in order to prevent the excessive wastage of electrical power.

1.4 Methodology

In order to design a motion-controlled switch to detect the movement of a person(s) or objects within a specified area, a RCWL-0516 proximity sensor was integrated with an Arduino microcontroller to detect movement under specified conditions such as clapping, waving of hands and even slow or rapid movement.

In order to prevent the excessive drainage of electrical power, a relay was used to control and automate the electrical appliances; input was continuously being taken from the proximity sensor to the Arduino which then was programmed into the Arduino IDE with various programming languages like C++, Java and Python. A loop statement was also included that instructed the opening and closing of the electrical circuit by the relay.

1.5 Scope of the Study

This project was concerned with the conservation of electrical energy in the Mountain Top University. Schematic diagrams was designed by Fritzing, an electrical circuit simulator, the project work was demonstrated with lightweight modules and also light load electronic equipments e.g. a Light bulb. The proposed system modules were coupled and connected on a breadboard, The Arduino IDE adopted programming languages like C++, Java and Python to write, compile and upload the program source codes to the Arduino Uno microcontroller board which served as the brain and heart of the designed system. Meanwhile, all the development corrections deemed necessary were made to the system and finally, the demonstration testing of this project was carried out within the Mountain Top University premises.

1.6 Significance of the Study

This project provided optimal solution to the problem of individuals, mostly students forgetting to turn off electrical appliances after making use of them or even when not in use at all. This project also solved the problem of electrical overload on the main source due to the accumulation of voltage from various electrical equipment/appliances occasionally connected to the mains supply. This was very beneficial to the electrical staff of the Mountain Top University as they would not be exposed to the strenuous activity of having to manually switch off electrical appliances in various lecture rooms and halls anymore.

By virtue of the completion of this project, the need to have to move to a certain location (possibly distant) in order to use the switch was totally discarded. For example, waving one's hand in order to switch on the table lamp during the night when awake from sleep became much easier than having to stumble in the darkness looking for the switch. This was even much better than having to use a remote-control device.

1.7 Definition of Terms

i. **Actuator:** A device that introduces motion by converting electrical energy into mechanical energy in an electro-mechanical system. (An actuator may likewise stop movement by cinching or bolting.) A dynamo is a case of an actuator.

ii. **Arduino:** A single-board microcontroller used for prototyping without having to deal with breadboards or soldering. The software to operate an Arduino is free and open source.

iii. **Arduino Uno:** The most popular and commonly used Arduino microcontroller module.

iv. **Bluetooth:** Short-range remote technology standard which works on the 2.4 MHz band. Bluetooth can be utilized for sending both information and sound, with well-known uses including wireless headphones and cordless consoles. Bluetooth gadgets can be set up with various equipment profiles to help perform some particular tasks, for instance sound card, sound, serial, and console profiles.

v. **Doppler Effect:** Otherwise called **Doppler Shift**. It is the adjustment in recurrence or wavelength of a wave in connection to an eyewitness who is moving in respect to the wave source. A typical case of Doppler shift is the difference in pitch heard when a vehicle sounding a horn draws near and subsides from a spectator. Estimated with the transmitted frequency, the frequency received is increased during the approach of, indistinguishable at the moment of cruising by, and lower as the vehicle moves farther away.

vi. **Energy-Harvesting Technologies:** Technologies which utilize minute quantities of energy from proximity to control small remote gadgets. Applications can be found in remote sensor systems or wearable tech. Energy sources include sun, wind, or kinetic energy among others.

vii. **Home Automation:** The automation of certain activities within a household. This can include automated control of lights, doors, and air conditioning.

viii. **LDR:** Light Dependent Resistor. This is a type of resistor whose resistance varies with level of exposure to light. This used to be called a "photocell".

ix. **Micro-Electro-Mechanical Systems (MEMS):** These are combinations of electric and mechanical components working together to provide several applications including sensing and actuating which are already being commercially used in many fields, mostly in the form of transducers and accelerometers.

x. **Proximity Sensor:** A sensor that can recognize the nearness of close-by articles without having any type of physical contact.

xi. **RCWL-0516:** A type of proximity sensor that operates at a very wide voltage range (4.0V-28.0V) and supports low frequency emission i.e. as low as 10Hz and extends even up to 3.181GHz.

xii. **Relay:** A switch that is electrically operated by an electromagnet. The electromagnet is usually activated with a low voltage e.g. 5V from a microcontroller and it pulls a contact to either make or break a high-voltage electric circuit.

CHAPTER TWO

LITERATURE REVIEW

2.1 General Overview

Internet of Things (IoT) term speaks to a general idea outlining the capacity of system gadgets to detect and gather information from around the globe, and after that offer that information over the Internet where it very well may be handled and used for different intriguing purposes. The IoT is made up of smart machines and devices associating, interacting and communicating with other different machines, devices, articles, protocols and frameworks. Nowadays every person is connected with each other using lots of communication means but the most popular communication way is the Internet, also known as The Web. So, in other words we can say that it's the Internet that connects people.

An extreme development of the present Internet into a network of interconnected objects that not just collects data from their surrounding environment (detecting) and associates with the physical world (activation/direction/control), yet additionally uses existing Internet protocols and standards to send and receive information, data analysis, application and communication among others (Gubbi, Buyya, Marusic, & Palaniswami, 2013).

IoT has grown out of its technological cocoon due to the preponderance of open wireless technology. Bluetooth, radio frequency identification (RFID), Wi-Fi, and telephonic data services as well as embedded sensor and actuator nodes to mention but a few. IoT has stepped out of its infancy and is on the verge of transforming the current static Internet into a fully integrated Future Internet (Sharma, & Tiwari, 2016).

Sensors can be implemented for the instrumentation and monitoring of environments, the tracking of assets through space and time, detection of various changes in the environment which have been defined to be useful, the semi-administrative control of a system with regard to being in a closed vicinity and in close proximity i.e. within a defined range of amendable change, and adapt services to improve their utility. (Möller & Networks. Springer, 2016). Sensors need to be designed with little effect on the physical quantity measured, which requires that the sensor be fabricated much smaller to reduce measurement error.

With the advent of new technology, sensors are now manufactured on a microscopic scale, such as micro-sensors that use the so-called MEMS technology. They range in size from nanometers to micrometers to millimeters and are fabricated as discrete devices or large arrays (McEvoy &

Correll, 2015). MEMS perform two different types of functions: as a sensor and as an actuator. Both sensors and actuators act as transducers, converting one signal to another, as discussed above. Of specific interest are transducers that convert environmental information into digital signals and vice versa (Muro, 2013). MEMS sensors can convert environmental information, such as temperature, humidity, and pressure, into an electrical signal. MEMS actuators work in reverse to sensors; they convert an electrical signal into physical information to move or control devices, such as motors, hydraulic pistons, and relays. These MEMS components have high resonant frequencies leading to higher operating frequencies (Poslad, 2011).

Many years ago, when there were no such thing as electrical control switches, electrical current was generated by manual means of rotating wheels which then produced varying electrical currents according to the speed of the wheels with time. As decades went by, more easily operated switches were brought into existence by technological advancement. From the wall switch normally used for lamps to the knife switches used for high voltage equipments and then to the gear switches invented for higher voltage connections. Then the automated switches came into existence starting from the automatic change-over switch and in no time, better more efficient modifications were added.

2.2 Conceptual Review

As a matter of fact, the proximity sensor operates by virtue of proximities. i.e. level of closeness to the sensor. But the type of proximity sensor is also important. In this project work, we had to make use of a proximity sensor with sensing ability at a maximum. i.e., the sensor was able to detect even the slightest movement. The voltage of device controlled by this system was determined by the relay’s capacity to control it. These criteria held very great importance in the development of this project work among others. Therefore, the concepts with relevance to this project work were outlined and discussed in this section to aid a better understanding of the project. These concepts included Internet of Things, Proximity Sensor, Circuit Switch, Arduino Microcontroller and Relay. This review also provided a guide on the approach to be adopted for the study.

2.2.1 Internet of Things (IoT)

The phrase "Internet of Things", also well-known as IoT for short was gotten from the two words; i.e. "Internet" and "Things". The Internet is a worldwide arrangement of interconnected PC networks that utilize the standard Internet Protocol suite (TCP/IP) to serve billions of clients around the world (Li, Da & Zhao, 2015). Even until this day, there has not been any specific or fixed definition for IoT that was accepted by the world community of computer users. As a matter of fact, a lot of individuals and groups including researchers, academicians, innovators, developers and practitioners in various fields have given various definitions according to their series of various findings by research or even sentiments to the term "Internet of Things". Kevin Ashton, a digital innovation expert made the first initial use of the term during his wordplay on supply chain optimization (IOT 2013).

All of the definitions shared a singularity which is the idea that the Internet was at first version, fixated around data created and generated by people, then by the next version, the Internet became about data created, generated and modified by things. So, from all gathered and processed knowledge gathered from this simple catchphrase, we could say that the best definition for the Internet of Things was: "An exposed and comprehensive network of intelligent objects that possess the capability to detect, interact with, auto-organize, share information, data and resources, taking rational decisions, actions and reactions prior to the given situations and changes in the environment" (Internet World Stats, 2011).

2.2.2 Proximity Sensors

A proximity sensor is a type of sensor that, with no physical contact, has the capacity to identify the closeness of nearby articles or persons. A proximity sensor worked by often emitting electromagnetic field waves or beams of electromagnetic radiation (e.g. infrared), and then, waited for changes in the field or return signal (Tiong, Ahmad & Goh, 2019). The object or mass to be sensed by the proximity sensor was often outlined as the sensor's target. Various proximity sensor targets require their respective proximity sensors. For example, an inductive proximity sensor demand a metal target.

Proximity sensors are said to be very reliable and functional for cumulatively a very long time because there are no mechanical parts or any form of physical contact between the sensed object and the sensor. Proximity sensors are very common with mobile devices. It causes the smartphone screen to sleep when it comes close to a human body and when the body is outside that close range, the screen of the mobile device "awakes" from sleep mode. But if the body is stationary or not moving, the sensor will then cease to notice the body/target and go back to sleep mode. For example, during a phone call, proximity sensors play a major role in detecting (and ignoring) accidental taps on the touch-screen by making sure the screen stays asleep when the phone is put to the ear by the user.

Proximity sensors also can be used to read and understand air gestures as well as hover-manipulations. An arranged group of proximity sensing elements can have depth camera-based or vision-camera solutions substituted for the hand gesture detection (Marcello & Piloni, 2019). Other applications of proximity sensors include: Automatic faucets (that releases water when it senses your hands), Ground proximity detection, measurement and warning system in the airport runways for the safety of aircrafts, Parking sensors (i.e. sensors mounted on car bumpers that detect distance to nearby cars for parking), Roller coasters (to keep them on their tracks), Mobile devices (i.e. Touch screens that switch off when coming in close proximity to the face or body of the operator, reduction of radio power in close proximity to the body, in order to reduce exposure to radiation from the mobile devices), etc.

2.2.2.1 Motion Detectors

Motion detectors are modules or devices that notice/detect moving objects, especially people. Such devices in most cases were often integrated as one component of a full system that automatically carried out a certain task, i.e. alerted a user of motion in an area or a series of tasks along with that certain task as the major task. They formed a very important component of automated lighting control, energy efficiency, home control, small scale, medium scale, large scale (advanced) security and other useful systems (Chandramohan, et al., 2017).

Motion detectors wove its wool into major sections in domestic and commercial applications. One very common application of motion detectors is activating automatic door openers in corporate structures and even public buildings. Motion sensors were also widely used in smart lighting systems e.g. in controlling street lights or indoor lights in walkways, such as lobbies, corridors and staircases. In such smart lighting systems, electrical energy was mostly conserved by keeping the lights on for a short but definite duration of time, after the person has left the detection area presumably. A motion detector may be included as one of the sensors in a burglar alarm (e.g.

buzzer) that alerted the owner of the house or security service when it detects the motion of any person, which may possibly be possibly an intruder. This kind of detector may also be set to trigger on a pre-installed security camera to record a live feed of the possible intrusion (Bharath, 2019). Several types of motion detection are in wide use. These include:

i. **Passive infrared (PIR):** PIR sensors detect persons by emitted radiation derived from skin temperature, in contrast to all other objects in the background at room temperature. The sensor emits no energy, hence the reason for its name passive infrared sensor.

ii. **Microwave radar:** This sensor detects motion through the principle of Doppler radar, and is slightly similar in features to a radar speed gun. Microwave radiation is emitted continuously, and when an object or a person moves towards or away from the receiver, there is a change of phase in the reflected microwaves and this results in the production of a low frequency signal (Sohn, 2015).

iii. **Ultrasonic:** An ultrasonic sensor works by emitting ultrasonic waves at a higher frequency than a human ear can hear by the means of its transducer and thus, obtains reflections of the wave from close by objects. Just like in the case of the Doppler radar, the slightest glitch in the received field indicates motion. The detected Doppler shift is also at low audio frequencies (for walking speeds). One potential setback of ultrasonic sensors is that the sensor can be sensitive even in areas where its detection is not needed, for instance, due to the reflection of sound waves around wall corners. Such extended detection coverage may be needed for lighting control, where the goal is detection of any movement in the area. But for the opening of an automatic door, a sensor that selectively faces the path toward the door is more likely preferable (Panda, Agrawal, Nshimiyimana & Hossain, 2016).

iv. **Video camera detection software:** With the availability of affordable surveillance cameras able to record videos, it is possible to use the output of such a camera to detect motion in its field of view using software. This solution is specifically attractive when the system is programmed to record video when triggered by detection of motion. As a matter of fact, no extra hardware is needed aside from the camera and computer. Since the path of coverage may be normally illuminated, this may still be seen as another passive technology. However, hybrid video cameras with infrared capability can be installed instead to detect motion in the dark, i.e. with the emission of a tiny red light sparingly detectable by a human eye that displays in grayscale video color.

2.2.3 Electrical Circuit Switches

An electrical switch was any device that permitted or disallowed the flow of electrons in a circuit. A switch was basically a binary device i.e. it could either be completely closed (on) or completely open (off). It was mostly operated manually, for instance, a light switch or a keyboard button. It was at times even operated by a moving object such as a door or even a gear, or by some sensing element for temperature, pressure or even humidity (Hsieh, Tsai, Su, & Juang, 2018).

A switch possesses one or more sets of contacts, which may preferably operate simultaneously, alternately, or sequentially and this is why high-powered circuit's switches must make use of a rapid-moving switch mechanism, preferably a spring-operated tipping point mechanism to ensure quick movement of switch contacts, regardless of the speed at which the switch control is operated by the user, and may also include special features to help step-down or perhaps interrupt very high electric current coming through the circuit.

The simplest kind of switch is that in which the electrical conductors (mostly two) are made to come in contact with each other by the movement of an actuating mechanism. Other switches containing electronic circuits able to turn on or off depending on some physical stimulus (such as light, temperature or magnetic field) sensed, are more complex switches. No matter what the case may be, the resultant output of any switch will at least, include a pair of wired terminals that will be set to either be in contact with one another in the switch's internal contact mechanism ("i.e. closed or on"), or not connected together ("i.e. open or off") (Slade, 2017).

A common application of this principle is in the installation of lighting control switches. Multiple switches may be connected to the same circuit to allow consistent and flexible control of lighting systems. A switch may be directly customized as a control signal to a system by the user, such as a computer keyboard button, or a wall switch so as to control power flow in a circuit. Automatically operated gear switches can be used to fully control the movement of machines.

Switches may also be controlled by factor variables such as temperature, current, voltage, flow, force, and pressure, playing a role as sensors in a process and used to automatically control a system. For example, a potentiometer is a resistance-operated switch used to control the voltage of a small electrical installation. A relay is a switch that is controlled by another electrical circuit. Some switches play the role of isolating electric power from an electrical setup, to prevent accidental operation of the setup during maintenance, or to even prevent electric shock (Ducruet & Mounier, 2006).

An ideal electrical switch would have no voltage rise drop whatsoever when closed, and would have no voltage limit or current rating. It would open and close zero-time duration, and would switch both positions without "bouncing" between on and off states. Practical switches on the other hand, fall short of this ideal; they have limits on the amounts of current and voltage they can handle, resistance, fixed switching time, etc. The ideal switch is often employed in circuit analysis because of how much it breaks down the system of calculations to be done, but this most cases produce a less accurate solution. There are various types of switches according to their design or operation mechanism. They include:

i. **Toggle Switches:** These switches are actuated by a lever set at various angles i.e. two or more angular positions.

ii. **Pushbutton Switches:** Pushbutton switches are switches actuated with a button that is pressed and released. Most pushbutton switches possess an internal spring-like mechanism returning the button to its “out,” or “un-pressed,” position, for operations at regular intervals.

iii. **Selector Switches:** Selector switches are activated with a rotating handle or switch of some likeness to choose one from at least two positions. Like the toggle (flip switch), selector switches can either stay in any of their positions or contain spring-return components for instantaneous operation.

iv. **Joystick Switches:** A joystick switch is designed as a lever that moves in multiple axes. One or a lot of many switch contact mechanisms are controlled counting on that approach to which the lever is pushed, and typically by however far it is pushed. Joystick hand switches are normally used for robot control, crane operation and automaton management.

v. **Proximity Switches:** Proximity switches sense the closeness of an approaching object or body either by very low or relatively high-frequency electromagnetic field. A simple proximity switch will make use of a permanent magnet to automate a sealed switch mechanism whenever the moving object or body gets close to its radar or even around its axis.

2.2.4 Arduino Microcontrollers

Arduino is open-source equipment. The equipment reference structures are circulated under a Creative Commons Attribution Share-Alike 2.5 permit and are accessible on the Arduino site. Design and creation records for certain adaptations of the equipment are likewise accessible.

In spite of the fact that the equipment and programming structures are openly accessible under copyright licenses, the designers have mentioned the name Arduino to be selective to the official item and not be utilized for inferred works without authorization. The official strategy report on utilization of the Arduino name stresses that the venture is available to consolidating work by others into the official item. A few Arduino-perfect items financially discharged have stayed away from the undertaking name by utilizing different names finishing off with "- duino".

Most of the various Arduino boards comprise of an Atmel 8-bit AVR microcontroller (ATmega8, ATmega168, ATmega328, ATmega1280, ATmega2560) with variant amounts of pins, flash memory, and even specification features (Badamasi, 2014). These boards utilize single or twofold column pins or female headers that encourage connections for programming and consolidation into different circuits that may interface with extra modules named shields. Arduino microcontrollers are pre-modified with a boot loader that streamlines transferring of projects to the on-chip flash memory. The default bootloader of the Arduino UNO is the optiboot bootloader. Boards are stacked with program code by means of a serial connection with another PC.

Recent versions of the Arduino boards are customized through Universal Serial Bus (USB), executed utilizing USB-to-serial connector chips, for example, the FTDI FT232. A few boards, for example, later-model Uno boards, substitute the FTDI chip with a different AVR chip carrying USB-to-serial firmware, which is reprogrammable by means of its own ICSP header. Other diverse variations, for example, the Arduino Mini and the Boarduino (unofficial trademark), utilize a separable USB-to-serial connector board or link cable, Bluetooth or several other techniques. At the point when utilized with conventional microcontroller devices, rather than the Arduino IDE, standard AVR in-system programming (ISP) is utilized in writing computer programs (Urban, 2014).

The Arduino board uncovers the vast majority of the microcontroller's I/O pins for use by different circuits. These pins are on the top-side of the board. The current Uno give 14 digital I/O pins, six of which can deliver pulse-width balanced signals, and six analog inputs, which can likewise be utilized as six digital I/O pins. A few module application shields are additionally available commercially for access. The Arduino Nano, and Arduino-perfect Bare Bones Board and Boarduino boards may include male header pins on the bottom-side of the board that can be plugged into solderless breadboards. Numerous Arduino-good and Arduino-inferred boards exist.

Some are practically identical to an Arduino and can be utilized conversely. Many upgrade the fundamental Arduino by including output drivers, regularly for use in school educational level, to make basic and comprehensive the making small control-based designs and little robots. Others are electrically proportional but however change the structure factor, sometimes keeping compatibility with shields, other times not. A few variations utilize various processors of various compatibilities.

2.2.5 Relays

A relay is an electrically controlled switch. Many relays utilize an electromagnet to precisely operate a switch, yet other standards for operation are likewise utilized, for example, solid-state relays. Relays are utilized where it is important to control a circuit by a different low-control signal, or where a few circuits must be constrained by one signal. The first relays were utilized in long distance broadcast circuits as amplifiers: they rehashed the signal rolling in from one circuit and re-transmitted it to another circuit and several decades later, relays were utilized widely in telephone exchanges and early computer systems to perform logical operators (Gurevich, 2018).

The type of relay that can deal with the high power required controlling an electric motor or different high current load directly is known as a “contactor”. Solid-state transfers control power circuits with no moving parts, rather utilizing a semiconductor device to carry out its switching process. Relays with aligned working attributes sometimes various operating coils are utilized to shield electrical circuits from overload or faults; in present day electric power frameworks these capacities are performed by advanced instruments still called "protective relays". Magnetic latching relays require one pulse of coil capacity to move their contacts in a single bearing, and another diverted pulse to move them back. Rehashed pulses from a similar input have no impact. Magnetic latching relays are helpful in applications where power interfered with ought not to influence the circuits that the relay is controlling (Coutier, 2009).

Relays are utilized whenever it is important to operate a high power or high voltage circuit with a low power circuit, particularly when galvanic separation is wanted. The first principal use of relays was in long broadcast lines, where the frail signal received at a moderate station could control a contact, recovering the sign for further transmission. High-voltage or high-current gadgets can be controlled with little, low voltage wiring and small, luminous switches. Administrators can be disengaged from the high voltage circuit. Low power gadgets like microprocessors can drive relays to control electrical loads past their immediate drive ability. In a motor vehicle, a starter relay permits the high current of the turning engine to be controlled with little wiring and contacts in the ignition key (Sankaran, 2018).

The utilization of relays for the intelligent control of complex switching frameworks like telephone exchanges was contemplated by Claude Shannon, who formalized the use of Boolean algebra to relay circuit structure in A Symbolic Analysis of Relay and Switching Circuits. Relays can play out the essential tasks of Boolean combinatorial logic. For instance, the boolean AND function is acknowledged by associating normally open relay contacts in parallel, the OR function by also interfacing normally open contacts in parallel. Reversal of a normal logical input should be possible with a normally closed contact.

Relays were utilized for control of computerized frameworks for machine devices and production lines. The Ladder programming language is regularly put into use for structuring relay rationale systems. Early electro-mechanical PCs, for example, the ARRA, Harvard Mark II, Zuse Z2, and Zuse Z3 utilized relays for rational logic and active registers. Be that as it may, electronic gadgets demonstrated quicker and simpler to utilize. Electromechanical switching frameworks including Strowger and Crossbar telephone exchanges utilized relays in subordinate control circuits. The Relay Automatic Telephone Company additionally fabricated telephone exchanges solely dependent on relay switching methods structured by Gotthilf Ansgarius Betulander. The originated open relay-based telephone exchange in the UK was introduced in Fleetwood on 15 July 1922 and operated until 1959.

Since relays are substantially safer than semiconductors to atomic radiation, they are generally utilized in security-based logic, for example, the control panels of radioactive waste-handling machinery (O’Regan, 2018). Electromechanical defensive relays are utilized to distinguish overload and other different faults on electrical lines by opening and shutting circuit breakers.

2.3 Theoretical Review

Investigating the relationship between Internet of Things, Proximity sensors, Electrical circuit switches, Arduino Microcontrollers and Relays has been examined through the lenses of various theories and outlines including theories of Circuit Switch Design, Doppler Effect, and Automated Switching (Proximity Switch). The rationale behind the use of each theory is described as follows:

2.3.1 Circuit Switch Design

A switch can be developed with any instrument moving two conductors into contact with one another in a controlled way. This can be as straightforward as permitting two copper wires to contact each other by the movement of a lever, or by legitimately pushing two metal strips into contact. In any case, a great switch configuration must be rugged and dependable, and abstain from giving the administrator the likelihood of electric stun (shock). Hence, modern switch structures are once in a while this rough. The conductive parts in a change used to make and break the electrical association are known as "contacts".

Contacts are commonly made of silver or silver-cadmium compound, whose conductive properties are not essentially undermined by surface corrosion, even oxidation perhaps. Gold contacts show the best resistance to corrosion, yet are restricted in current-conveying capacity and may weld together even in the absence of heat whenever united with high mechanical power (Sankaran, 2018). Whatever the decision of metal, the switch contacts are guided by an instrument guaranteeing square and even contact, for most extreme dependability and least resistance.

Contacts, for example, the above explained types can be developed to deal with incredibly a lot of electric flow, up to a huge number of amps at times. The constraining components that determine the maximum current, in amperes, that a conductor can carry continuously under the conditions of use without exceeding its temperature rating of the switch contact are stated as per the following:

i. Level of heat produced by current through metal contacts (while shut).
ii. Occurrence of electrical sparks when contacts are opened or shut.
iii. The voltage crosswise over open switch contacts (capability of current bouncing over the gap).

The most common type of switch is a physically controlled electromechanical gadget with at least one or more collection of electrical contacts, which are associated with outer circuits. Each arrangement of contacts can be in one of two states: either "shut" which means the contacts are contacting and power can stream between them, or "open", which means the contacts are isolated and the switch is not conducting electricity.

The component impelling the change between these two states (open or shut) are usually (there are different sorts of activities) either an "alternate activity" (flip the switch for persistent "on" or "off") or "flashing" (push for "on" and discharge push for "off") type. Any sort of switch contact can be planned with the goal that the contacts "close" (set up coherence) when impelled, or "open" (intrude on congruity) when activated. For switches that contain a spring-return mechanism in them, the bearing that the spring returns it to with no force applied is known as the ordinary position.

Along these lines, contacts that are open in this position are considered "normally open" and contacts that are shut in this position are called "normally closed". For procedure switches, the ordinary position, or state, is what the switch is in when there is no procedure effect on it. A simple method to make sense of the ordinary state of a procedure change is to consider the condition of the switch as it sits in its packaging box, uninstalled. Here are a few instances of "ordinary" process switch conditions:

i. Temperature switch: Ambient (room) temperature.
ii. Speed switch: Shaft not turning.
iii. Pressure switch: Zero applied pressure.
iv. Flow switch: Zero liquid flow.
v. Level switch: Empty tank or bin.

It is critical to separate between a switch's "typical" condition and its "ordinary" use in a working procedure. Consider the case of a fluid stream switch that fills in as a low-stream alarm in a cooling water framework. The ordinary, or appropriately working, state of the cooling water framework is to have genuinely steady coolant stream through this pipe. On the off chance that we need the stream change's contact to shut in case of lost coolant stream (to finish an electric circuit which initiates a caution alarm, for instance), we would need to utilize a flow switch with typically-shut (normally-closed) instead of regularly-open (normally-open) contacts. At the point when there's sufficient move through the pipe, the switch's contacts are constrained open; when the stream rate drops to an anomalous low dimension, the contacts come back to their normal (closed) state.

2.3.2 Doppler Effect

The Doppler Effect (or the Doppler shift) is the adjustment in frequency or wavelength of a wave in connection to an onlooker who is moving in respect to the wave source. It is named after the Austrian physicist Christian Doppler, who depicted the term in 1842. A typical case of Doppler move is the difference in pitch heard when a vehicle sounding a horn approach and subsides from an onlooker. Contrasted with the transmitted frequency, the received frequency is higher at the period of approach, indistinguishable at the moment of passing by, and lower during the subsidence.

The purpose behind the Doppler Effect is that when the origin of the waves is moving towards the spectator, each progressive wave peak is transmitted from a position nearer to the onlooker than the peak of the past wave. In this manner, each wave sets aside somewhat less effort to achieve the spectator than the past wave. Consequently, the time between the landings of progressive wave peaks at the spectator is decreased, causing an expansion in the frequency. While they are travelling, the separation between progressive wave fronts is decreased, so the waves "pack together". On the other hand, if the origin of waves is moving far from the eyewitness, each wave is transmitted from a position more remote from the onlooker than the past wave, so the arrival time between progressive waves is expanded, lessening the frequency. The separation between progressive wave fronts is then expanded, so the waves "spread out".

For waves that spread and expand in a medium, for example, sound waves, the velocities of the spectator and of the source are with respect to the medium in which the waves are transmitted. The cumulative Doppler Effect may subsequently result from movement of the origin of the waves, movement of the spectator, or movement of the medium. Every one of these impacts is analyzed independently. For waves which do not require a medium, for example, light or gravity in general relativity, just the relative distinction in speed between the spectator and the source should be considered.

2.3.3 Automated Switching (Proximity Switch)

Proximity switches open or close an electrical circuit when they reach or come extremely close to an object. They are most normally utilized in assembling gear, manufacturing equipments, mechanical technology, and security frameworks. More intricate proximity switches work like a metal detector, empowering a loop of wire with a high-frequency current, and electronically checking the amount of that current. On the off chance that a metallic part (not really magnetic) draws near enough to the coil, the current will increment, and trip the observing circuit. There are basically 4 kinds of proximity switches: infrared, acoustic, capacitive, and inductive.

Infrared proximity switches work by conveying light emissions of infrared light. A photo-detector on the proximity switch distinguishes any reflections of this light. These reflections permit infrared proximity switches to decide if there is a nearby object. As proximity switches with only a light source and photodiode are vulnerable to false readings because of background light, increasingly complex switches adjust the transmitted light at a particular frequency and have receivers which just react to that frequency. Much progressively complex proximity sensors can utilize the light reflected from an object to detect its distance from the sensor.

Acoustic proximity switches represent sensors which are comparative on a basic level to infrared models but however, utilize sound rather than light. They utilize a transducer to transmit imperceptible sound waves at different frequencies in a preset succession, at that point measure the period of time the sound takes to hit an object nearby and come back to the other transducer on the switch. Basically, acoustic proximity sensors measure the time it takes for sound pulses to "reverberate" and utilize this estimation to ascertain distance, much like the sonar put into application in submarines.

Capacitive proximity switches detect distance to objects by distinguishing changes in electrical capacitance around it. A radio-frequency oscillator is made to be in contact with a metal plate. At the point when the plate comes close to an object, the radio frequency changes, and the frequency identifier sends a signal instructing the switch to open or close. These closeness switches have the detriment of being more delicate to objects that conduct electricity than to objects that do not.

Inductive proximity switches detect distances to objects by producing a series of magnetic fields. They are comparative on a basic level to metal detectors. A loop of wire is charged with electrical current, and an electronic circuit estimates this current. In the event that a metallic part draws near enough to the loop, the present will increment and the proximity switch will open or close likewise. The main impediment of inductive closeness switches is that they can only distinguish metallic items.

Another type of proximity switch is the optical switch, consisting of a light source and photocell. Machine position is identified by either the interference or impression of a light beam. Optical switches are additionally helpful in security applications, where light emissions can be utilized to distinguish human movement into a hazardous zone. Proximity switches are utilized in a wide range of assembling processes. A few models incorporate estimating the situation of machine components, security frameworks, in applications, for example, like identifying the opening of an entryway, and in applied autonomy and robotics, where they can screen a robot or its segments' proximity to items and steer it likewise.

2.4 Review of Related Works

In the journal, “Automatic Electrical Appliances Control Panel Based on Infrared and Wi-Fi: A Framework for Electrical Energy Conservation” it was stated that “The changing paradigm in home automation was also that a device was no longer disconnected from the power grid. The function of the switch on the wall or even in the device was taken over by a network which was solely for signaling events. The network which controlled devices by transmitting datagrams was powered with a much lower current” (Adetiba, et al., 2011).

Their work entailed the design and implementation of a prototype of an infrared and Wi-Fi-based electrical appliances control panel whose circuit consisted of two systems: the sensory system (consisting of the infrared sensors, charging system, seven-segment LED display screen, microcontroller 1, digital signal transmitter and their respective charging systems.) and the switching system (consisting of microcontroller 2, relays, transistors, digital signal receiver and their respective charging systems.) which worked collectively to regulate the switching and control of frequently used electrical appliances e.g. light bulbs and electric fans in a room according to the incrementing or decrementing number of occupants in that room.

However, their publication was only a prototype and how the real design was derived was not comprehensively stated or demonstrated in anyway. There were also prototypes for future improvements which were not comprehensively outlined.

In the publication “A Review on Internet of Things”, it was stated that “IoT also provided “Do-It-Yourself” solutions for home automation which aided the remote control of home appliances prior to specified needs” (Farooq et al., 2015). Proper monitoring of utility meters, energy and water supply provided to the adequate conservation of resources, detection of unchecked water leaks etc. Also, with the inclusion of proper encroachment detection systems, there was a rapid drop in the rate of burglaries. Enabling of gardening sensors helped to measure the light, humidity, temperature, moisture and other important gardening vitals, as well as watering the plants adequately.

This implied that Internet of Things simplified the control of appliances in the home; hence eliminating manual modes of operation and the strenuous downsides that came with it. However the downsides were that since IoT connected people and things together, it also exposed them to malicious attacks from virtually, anywhere. i.e. RFID tags could be accessed by unauthorized users, even the Wireless sensor nodes and even the Cloud.

In the publication titled "Automatic Streetlights that Glow on Detecting Night and Object using Arduino", it was outlined that "The traditional lighting system was limited to two options; ON and OFF only. This then became a huge disadvantage especially to high voltage lamps because this meant power loss due to continuous operations on maximum voltage. Hence, wastage of power from street lights was one of the noticeable examples of power losses. But with the use of automation, energy and money was saved" (Mumtaz et al., 2018).

Explanatively, this outlined that the most natural solution was to control the street lights according to the outside lighting condition. A smart lighting system made this possible by being programming the street lights to turn OFF when there were no detections of movement or during the day-time, otherwise the lights remained Dim/ON. Its proposed design was aimed at replacing the manually-controlled light systems with efficient, automated lighting control systems. This was accomplished with the proper setups of the Arduino Uno microcontroller, IR obstacle avoidance sensor, Light Dependent Resistors (LDR), and Relays. In this scenario, when the intensity of sunlight impinged with LDR, street lights could be further controlled as per the desired requirement, automatically. Most importantly, a counter was set to count the number of vehicles/objects passing through the road, which was displayed on the serial monitor of Arduino IDE. Moreover, the high-intensity discharge street bulbs were replaced with LEDs to further reduce the power consumption.

An automatic street light system did not only help in reducing the power consumption, but also reduced accidents, criminal activities and maintenance costs. The street light systems were based on LDR, and most of them were passive infrared receiver-based systems that were controlled with timers and analog circuits. Sun tracking sensors were also utilized to power OFF the street lights by the detection of the sunlight luminance. Distinguished from turning ON/OFF the electricity, another approach was introduced to dim the light in fewer traffic hours that was useful to reduce the power consumption, but the electric bulbs were in continuous usage condition.

In this publication, the program source codes were not included and there still lay an urgent need to design a system that controlled the dim light, connected the power ON/OFF with the vehicle's motion detection, calculated the total number of vehicles passed through the road, and controlled the entrance gate at night to reduce criminal activities.

In the project work on the topic “Scalable Low-Cost Monitoring and Data Collecting Mesh Sensor Network”, four basic design options were briefly outlined and summarized for a scalable, low-cost monitoring and data-collecting mesh sensor network. The common design features all four designs shared in common was also briefly looked at. One of the main features outlined was that a solar panel was used in combination with a battery through a charge controller to power each sensor node. Also, each design implemented the ZigBee protocol for communication in each respective mesh network configuration.

It was also stated that all the proposed designs made use of a plastic, UV resistant enclosed covering to protect the contents of each node from the outdoor weather, each node had a microcontroller “brain” that was in charge of handling the habitual routine activities within the node and finally, the cumulative information gotten from each node was sent to a base station where it was stored in a .csv (comma-separated-value) file, later to be mapped for display, documentation and manipulation (Haddon, Owen, & Kamar, 2019).

The limitation to this project was that it was not explanative enough, lacked comprehensiveness and some of the proposed designs were not very affordable even as low-cost designs.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter aimed at comprehensively outlining the methodological processes involved in the design and implementation of a proximity sensor-controlled switch using Internet of Things (IoT) Technology and also included a lot of added comprehensive information like the reason why the proposed system outflanked the existing system of switch operation and control, analyzed the existing system, stated its limitations and also justified the acceptance of the proposed system.

3.2 System Development Model

This project adopted the Iterative Waterfall model which was a well-to-do SDLC method. This model was split into several phases:

The first phase was the **Requirement Analysis and Specification** phase. Before the proposed system or software was designed, a framework plan was arranged that contained necessary details to begin with the design. This phase dealt with identifying the problems facing the current system and also outlined the criteria that need to be met. The requirements of this system included:

i. A hardware implementation of a better viable system to replace the current outdated one.

ii. A system that could monitor the movement of persons around a specified area.

iii. A system which could automate the turning on and off of switches.

iv. A system that would conserve electrical energy and also the physical energy of the system user. i.e. an energy conservative system.

v. A more developed system that would integrate with the major actuation mechanism of the existing system.

The second phase of this model was the **Design** phase. This system illustrated the design of the system with the use of various diagrams including Activity Diagram, Flow Chart Diagram, and Use Case Diagram among others.

The third phase of this model was the **Implementation** phase. The design was then put into actualization in this phase. i.e. all hardware equipment tools were coupled together and were integrated with the programmed source codes to bring the system alive.

The fourth phase of this model was the **Testing** phase. In this phase, the designed system, already implemented was tested with various instances and data samples to observe several features and therefore conclude whether it was ready for deployment.

The fifth phase of this model was the **Deployment** phase. After the testing phase has been completed and the developed system has passed all given performance evaluation assessment tests, it was then deployed (or commercialized) to places where it was needed for setup and installation.

The sixth and final phase of this model was the **Maintenance** phase. This phase involved the improvement of the quality of the system and its components. NOTE: Some of the system components were maintained by software updates while others were maintained by hardware upgrades.

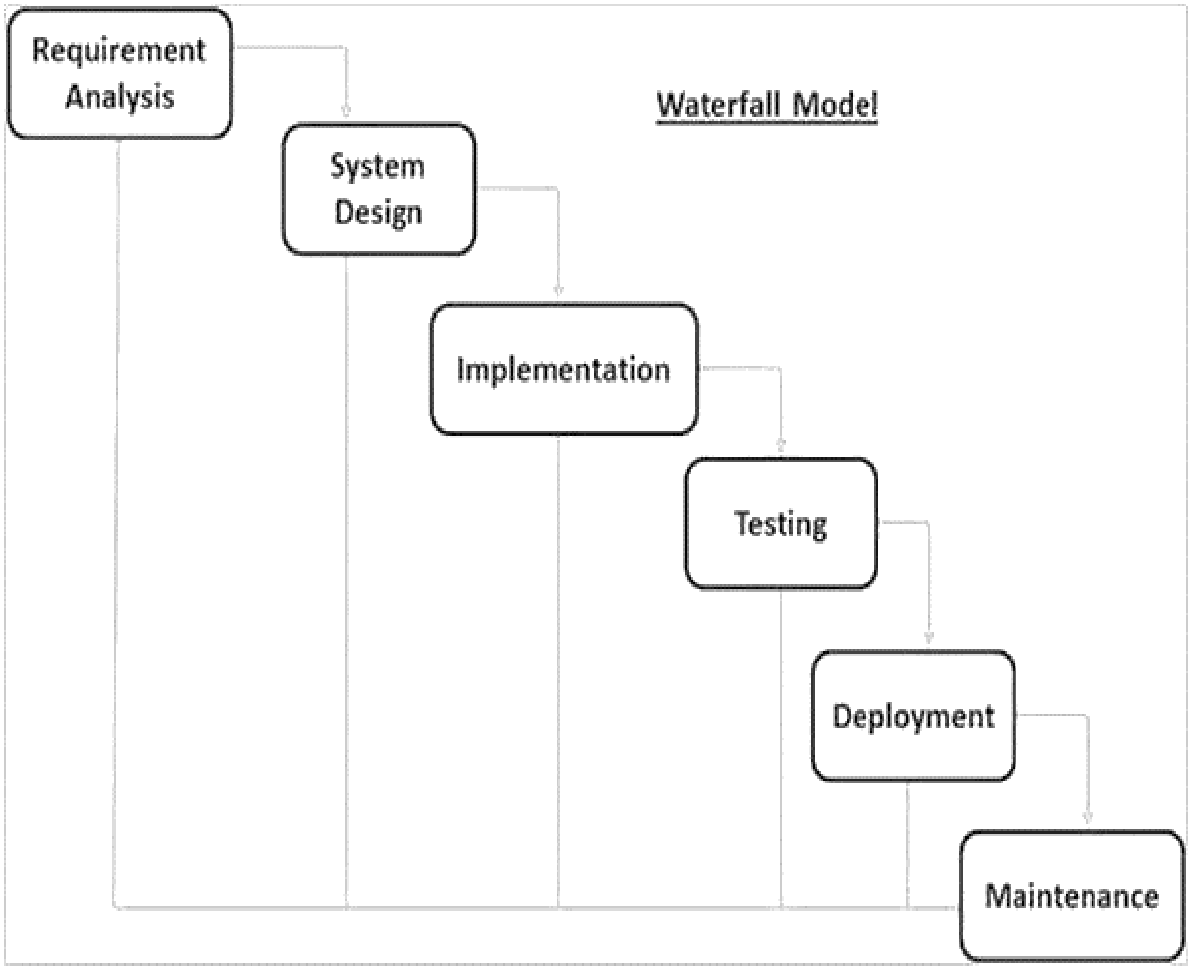

Figure 3.1 Waterfall model.

3.3 Analysis of Existing System

The existing system in the case study was the very common archaic and already outdated manual switching system. This was usually actuated by operating the switch by hand in order to switch on or otherwise switch off. This system was in use for over a century and had dominated for far too long although not the best solution and had to be replaced with a far better and more efficient system.

3.3.1 Limitations of Existing System

This system was known to be error prone, strenuous to use and inefficient at times. The user most times encountered problems with this system especially when the switch was at a position distant or unknown to the user. With the elimination this system, the user was relieved of the stress involved in having to walk to the location of the switch to switch it on. In fact, the whole process could be made to happen in a better way and a lot faster, even from the entrance to the area. At the end of the completion of the current system's cycle, the user had to walk into the room and to the location of the switch to turn it on and also turn it off when not in use anymore.

3.4 Justification of Proposed System

The proposed system in the case study was an automated switching system. This meant that this new system entailed that switching on or off according to preference of the user was done automatically. This system brought solutions to the problems outlined in the existing system and by doing so, served to accomplish some objectives. These objectives that the newly proposed automated system achieved included:

i. A stress-free switching control system that did not require the user having to walk to and from the direction of the switch.
ii. An automated system which worked with input from the presence or absence of movement.
iii. A time-conservative system.
iv. A highly efficient system that turned on immediately it detected motion in form of input.

3.4.1 Concept of Proposed System

The proposed system consisted of various subsystems and components that had to communicate with one another in order to make the system a functional system. This system was designed in such a method that various hardware devices interacted at unit level in every phase of development then cumulatively integrated into one another via Internet of Things (IoT) technology to make up the automated switching technology (proximity sensor-controlled switch) at system level.

3.5 System Components

This outlined the required software and hardware equipment tools which were required for use in the cause of this project work. The system requirements were subdivided into two classes:

3.5.1 Software Components

i. **Windows 7, 8 or 10 Operating system:** Windows 10 OS was installed on the computer which was used for this project work. This was because of the improved interface design and more advanced security improvements and also automatic updates.

ii. **Arduino IDE:** The program code involved imported C++ libraries, some Java methods and fewer Python called-in methods meant for the manipulation of the modules was written into the Arduino microcontroller using this IDE. The Arduino IDE contained all configurations of the Arduino microcontroller boards including the Uno with various drivers and module setups.

3.5.2 Hardware Components

i. **RCWL-0516 microwave proximity sensor:** For the detection of moving people or objects. i.e. motion detection. The RCWL-0516 detection range was about 270° when faced towards the detection direction.

ii. **Arduino Uno microcontroller:** This was the brain and heart of the system. The codes were sent from the IDE to the Arduino microcontroller for implemental execution.

iii. **SRD-05VDC-SL-C:** This was the 5v relay module used for the automated switching on/off of the electrical equipments or appliances connected to the switch. The live wire of the equipment was cut into and connected to the relay in order for the relay to allow or disallow the flow of electricity into the equipment or device depending on the instruction given to it by the Arduino microcontroller.

iv. **Medium size solderless breadboard:** This was used to arrange the pins neatly and also loop one pin to another port without having to short-circuit any connection.

v. **Dupont jumper wire cables (Female/Male):** These were used to connect one pin to another on the breadboard and to the other hardware components.

vi. **60W Light bulb with lamp holder wired to an electric plug:** This was used to test the system's validity.

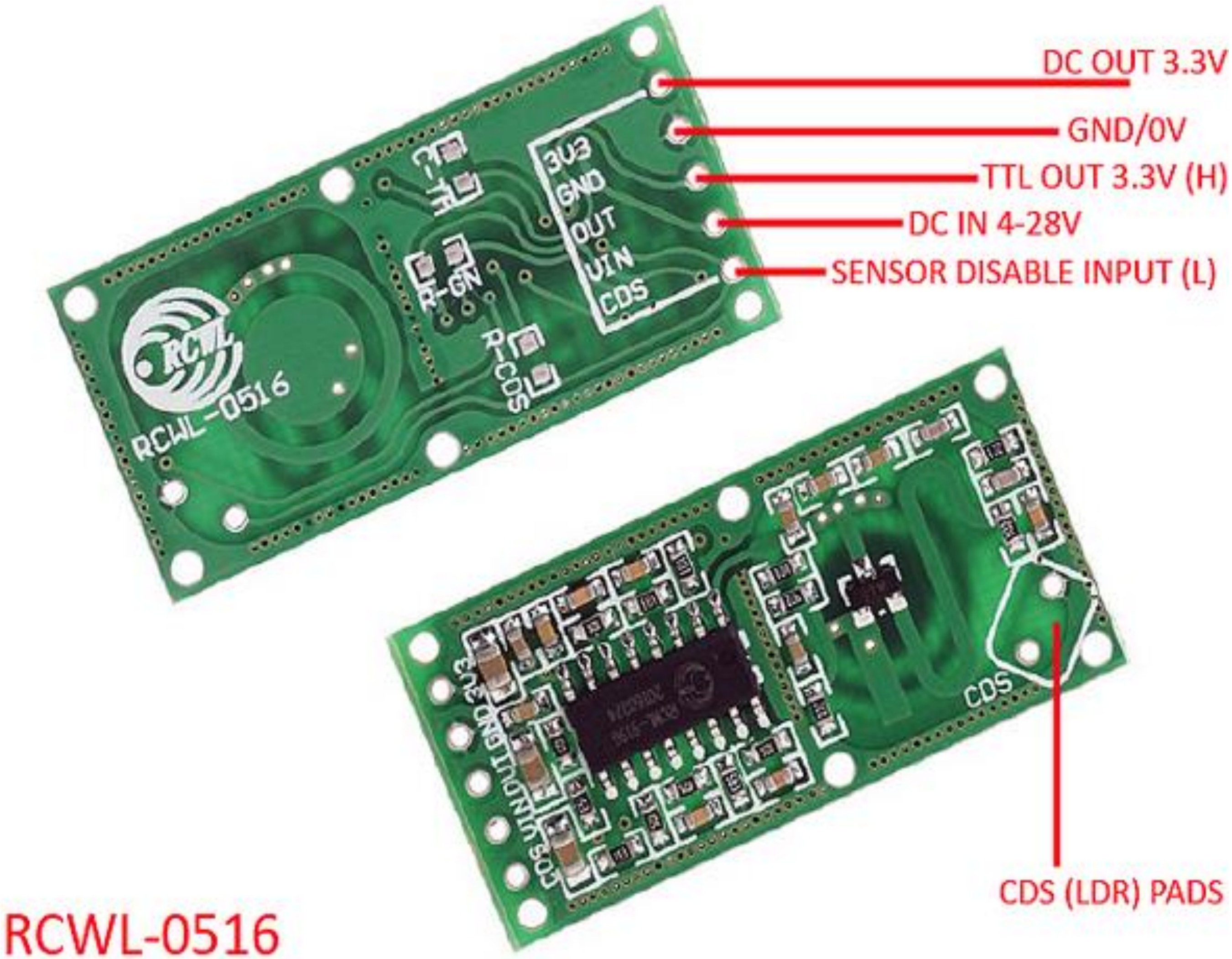

Figure 3.2 RCWL-0516 microwave proximity sensor (Anon, 2019).

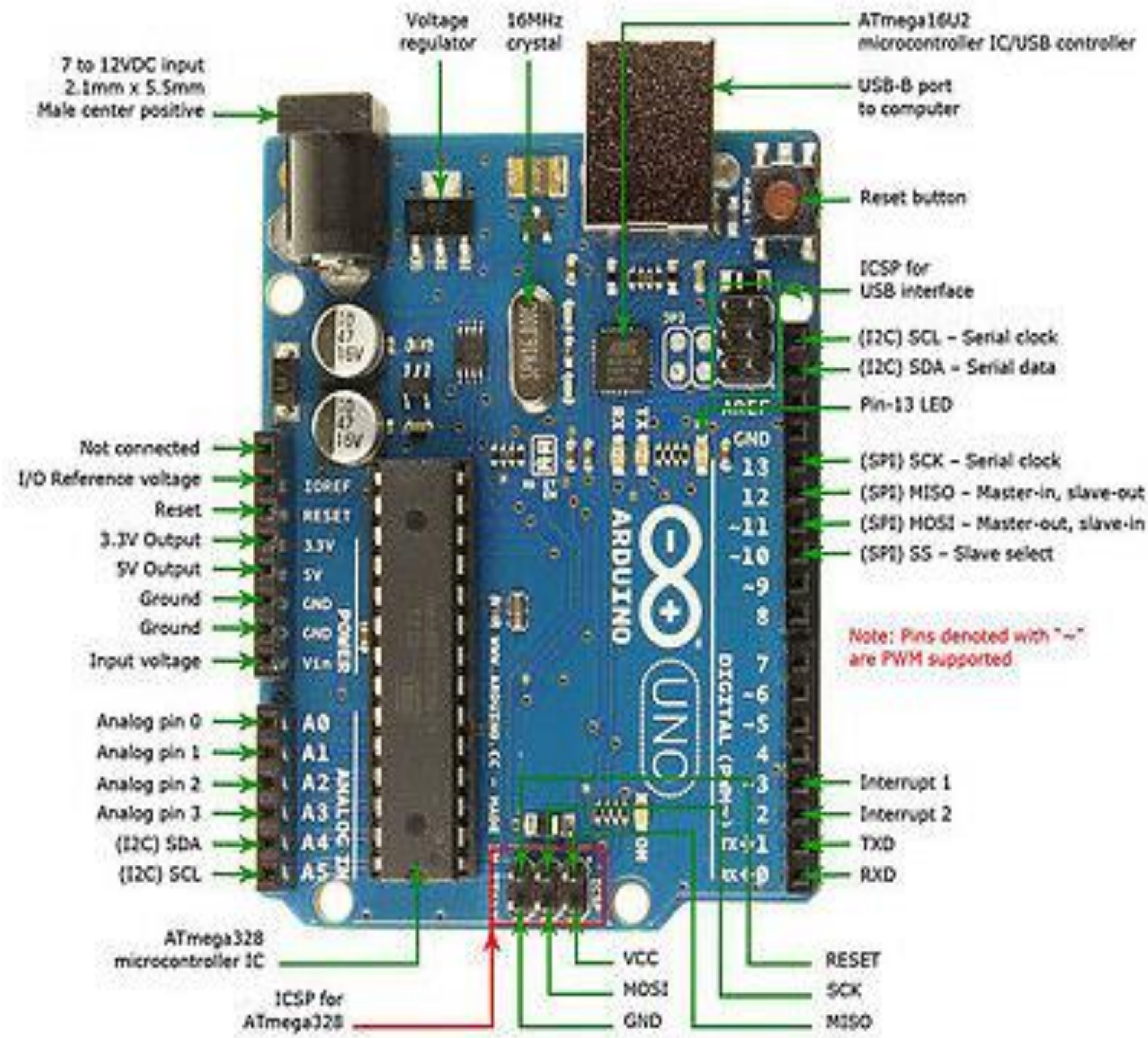

Figure 3.3 Arduino uno microcontroller (Arduino, 2015).

Figure 3.4 SRD-05VDC-SL-C relay module (Muqueet, 2019).

Figure 3.5 Dupont jumper cables (male and female pins) (Nussey, 2013).

Figure 3.6 Light bulb attached to an electric plug (Shutter Stock, 2019).

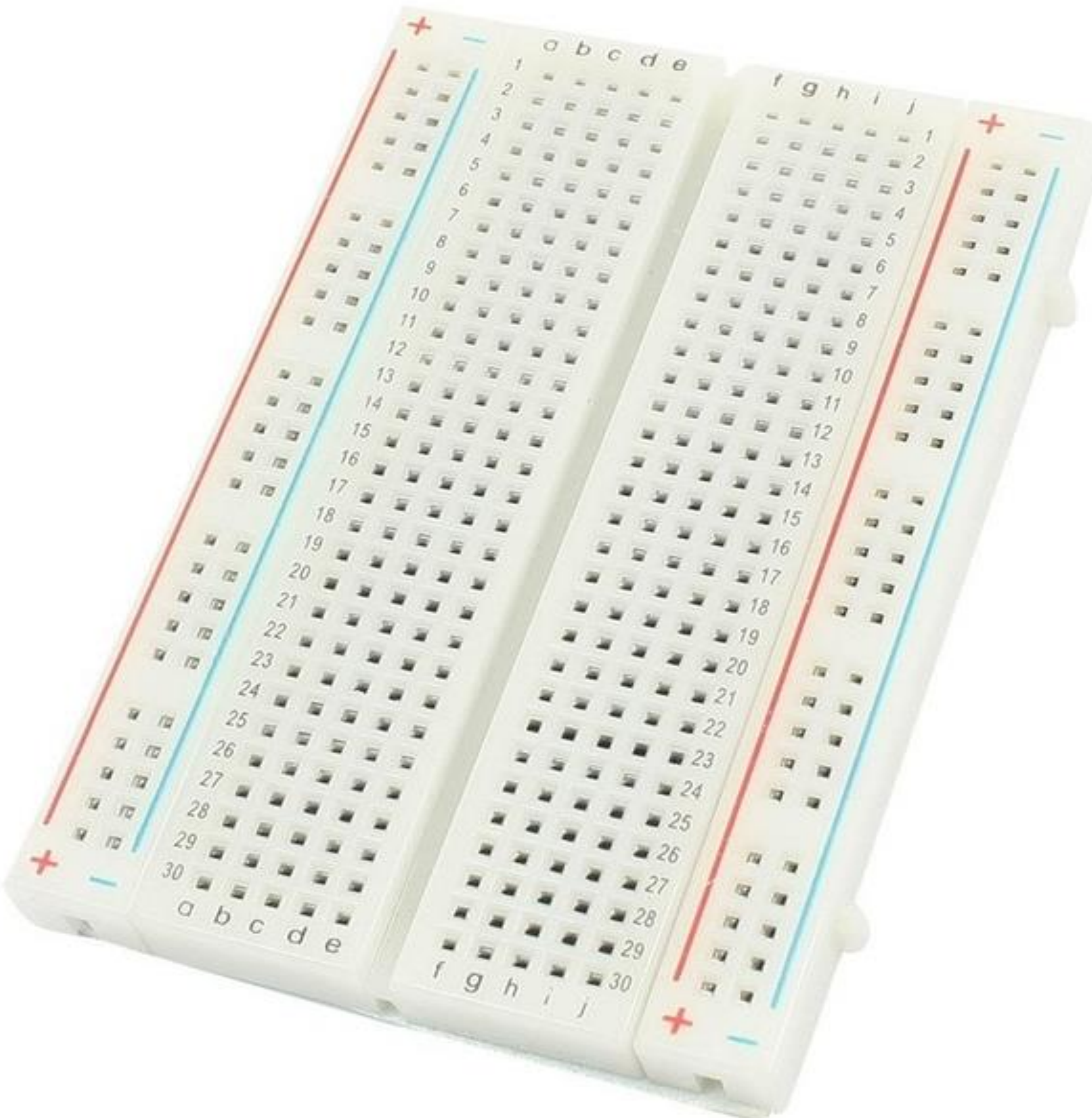

Figure 3.7 Solderless Breadboard (Cook, 2015).

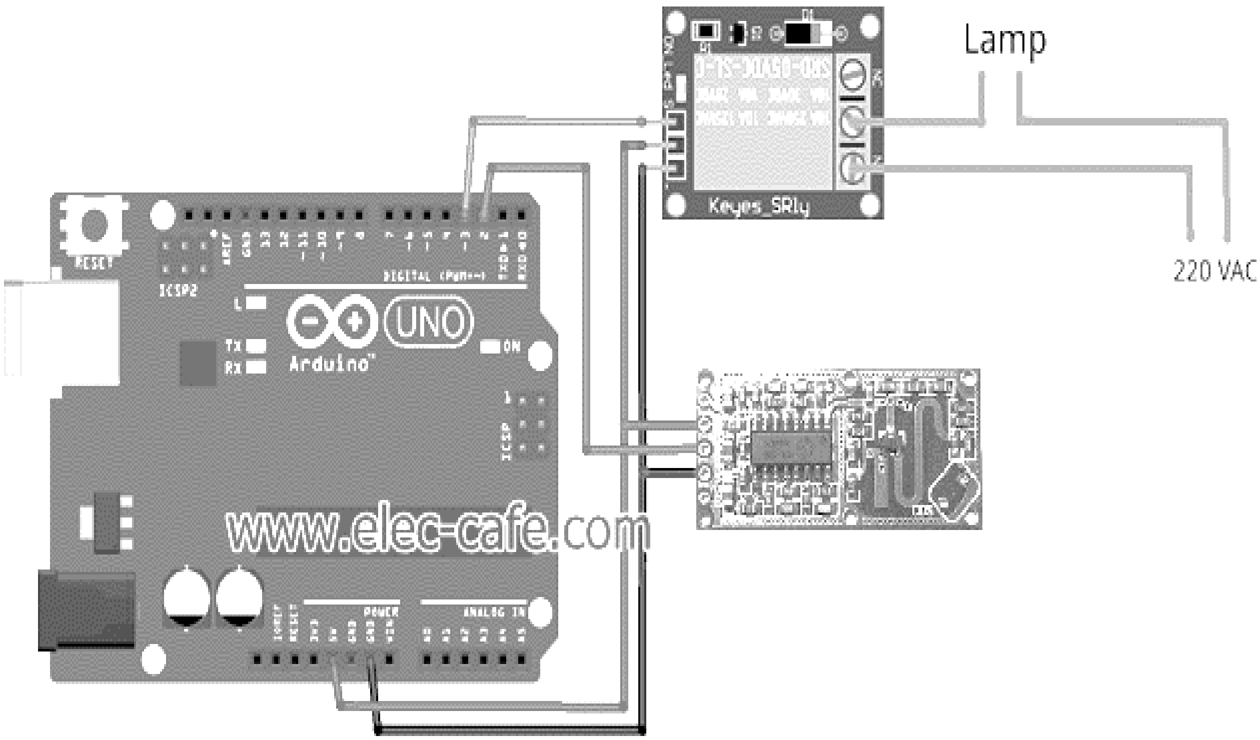

Figure 3.8 Schematic diagram of proposed system (Elec-Cafe, 2019).

3.5.3 Proposed System User Capabilities

i. **User Control:** The user was able directly control the switch by moving towards or away from the detection radar of the proximity sensor.

ii. **Flexibility in replacement of sensor-controlled device:** The user was also able to effectively replace the electronic appliance that the proximity sensor-controlled switch was actuating by physically disconnecting the device from the wire terminal on the relay.

iii. **Timer Capability:** The user was also able to re-adjust the time duration of which the switch was to remain on for after motion can no longer be detected by the proximity sensor.

3.5.4 System Features

i. **Timer Reset:** The system time duration before switch off was able to reset and restart itself when motion was detected before the end of the time duration.

ii. **Motion Detection:** The system was able to detect moving objects and send signals.

iii. **Software Quality and Usability:** The system was very user friendly, interoperable and flexible.

3.6 System Modelling

This system design was illustrated by several modelling diagrams in order to show an abstract representation of the developed proximity sensor-controlled switch.

3.6.1 Activity Diagram

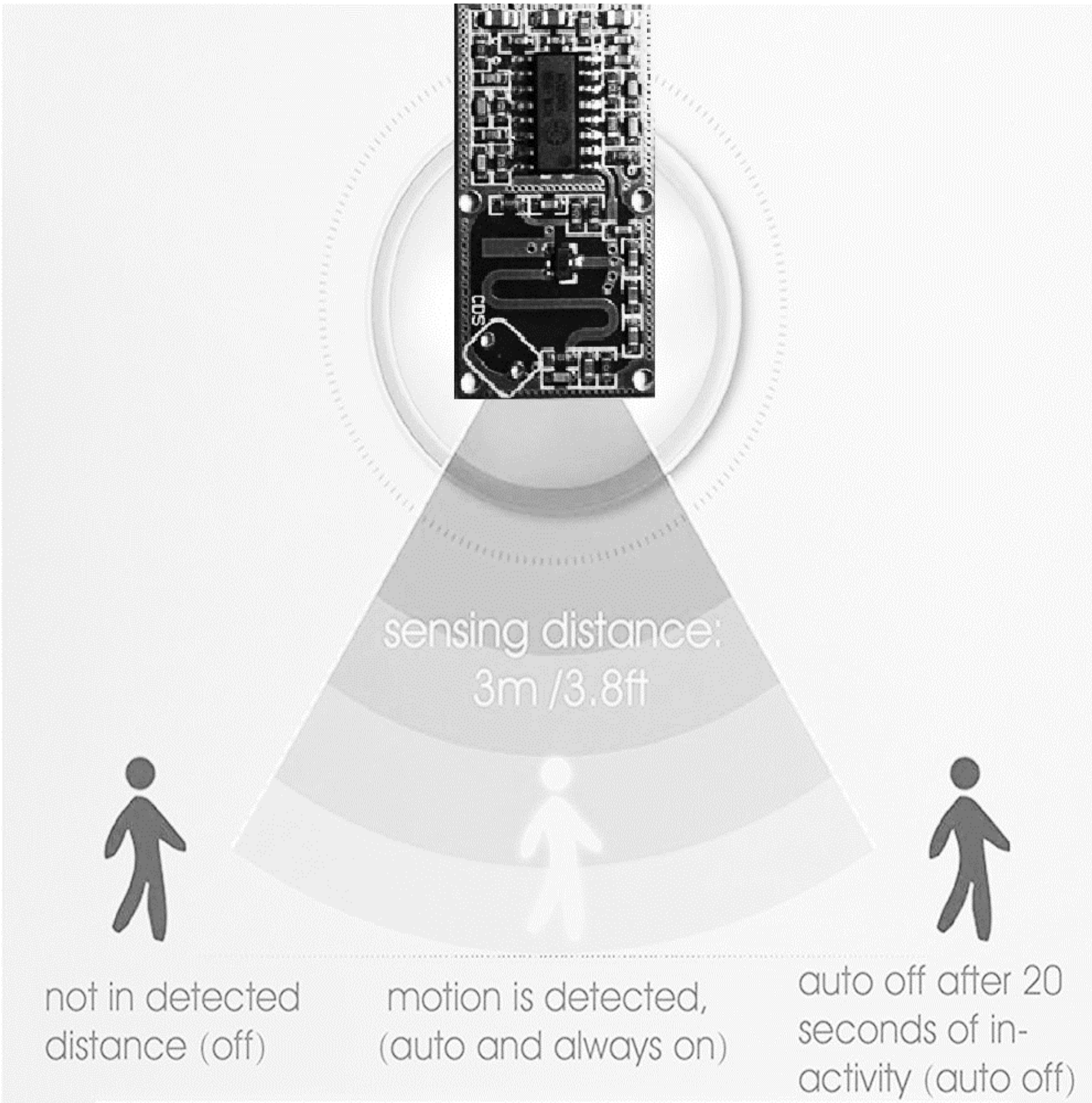

Figure 3.9 Activity diagram of proposed system

3.6.2 Flowchart Diagram

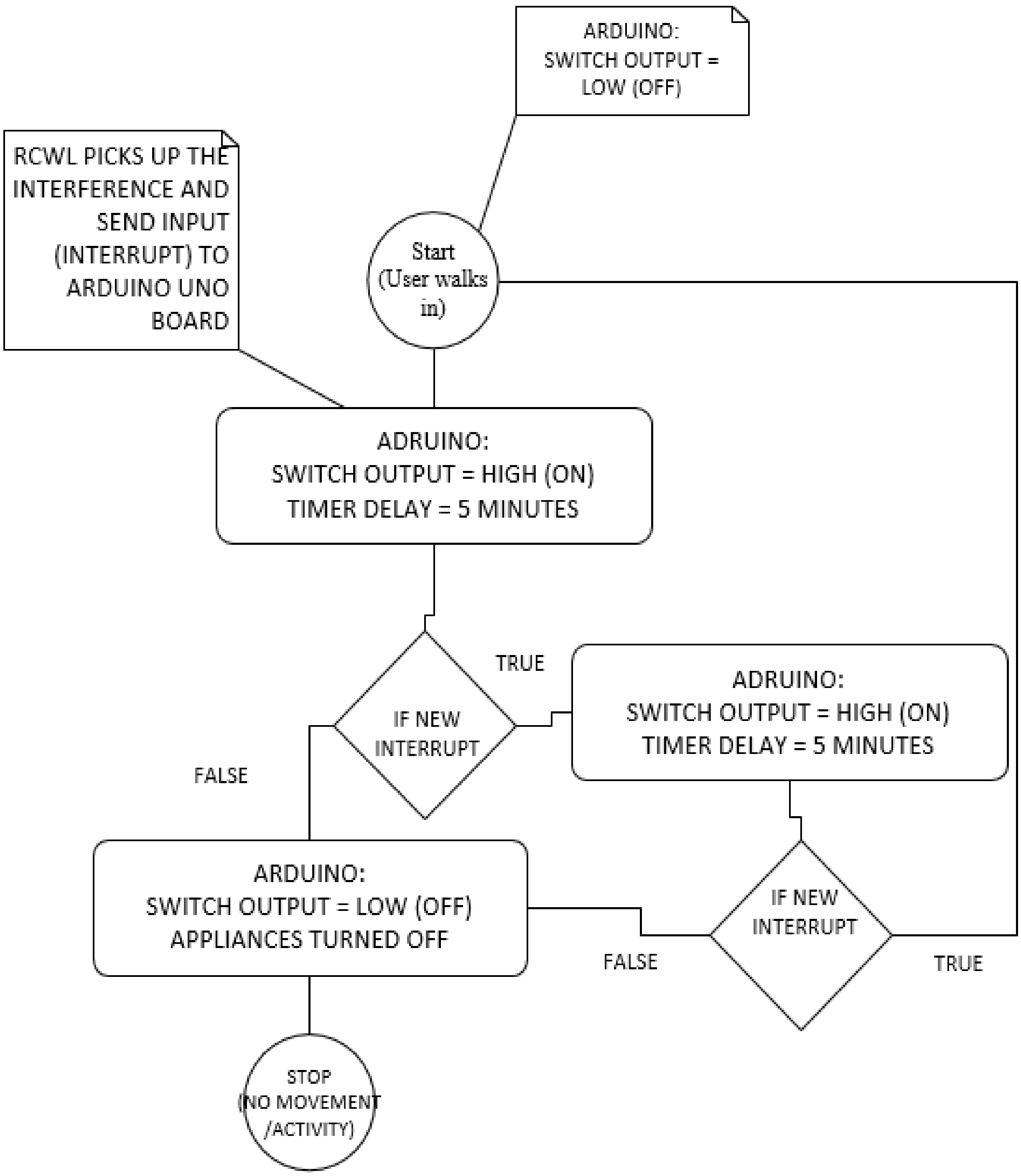

Figure 3.10 Flow chart diagram of proposed system.

3.6.3 Use Case Diagram

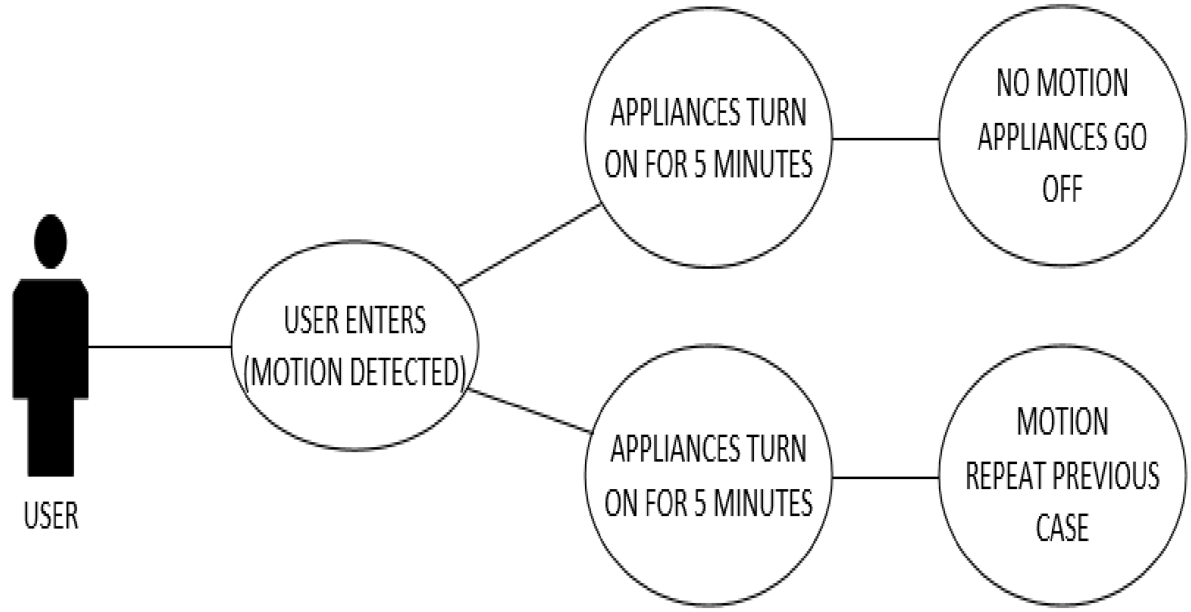

Figure 3.11 Use case diagram of proposed system.

CHAPTER FOUR

RESULTS AND RESULTS DISCUSSION

4.1 Introduction

This chapter buttressed on the coupling together of the various system components and implementation of the system proper. It also displayed the derived results, discussed briefly on the setup of the components of the system before assembly of the system to achieve the aim and objectives of this project work and how those results were derived, presented and documented.

4.2 Documentation of the System

Before the proposed system was designed, the following steps were taken:

i. The computer system was turned on and made to install windows 10 OS and boot to windows.

ii. The Arduino.exe setup file was installed on the computer system containing the windows 10 OS.

iii. When the installation was done, the Arduino application was opened and made to boot to new sketch workspace.

iv. The Arduino microcontroller was connected to the computer via Serial - USB connection.

v. The Device Manager of the computer system was opened in order to check for the correct COM port which the microcontroller was connected to.

vi. The correct COM port was selected from the "Port" drop down tab in the the Arduino IDE menu and all needed Arduino libraries were searched for and all updated in the "Manage Libraries" tab under the "Tools" drop-down tab.

vii. The modules were connected to the Arduino Uno microcontroller one after the other in a single manner and tested with various pre-installed code examples.

viii. The program source code for the system was written into the Arduino IDE workspace as new sketch.

ix. The code was then compiled as a sketch and the sketch uploaded to the Arduino microcontroller Board.

x. Then the Arduino IDE serial monitor was opened and used to check the operation of the system while the hardware was executed.

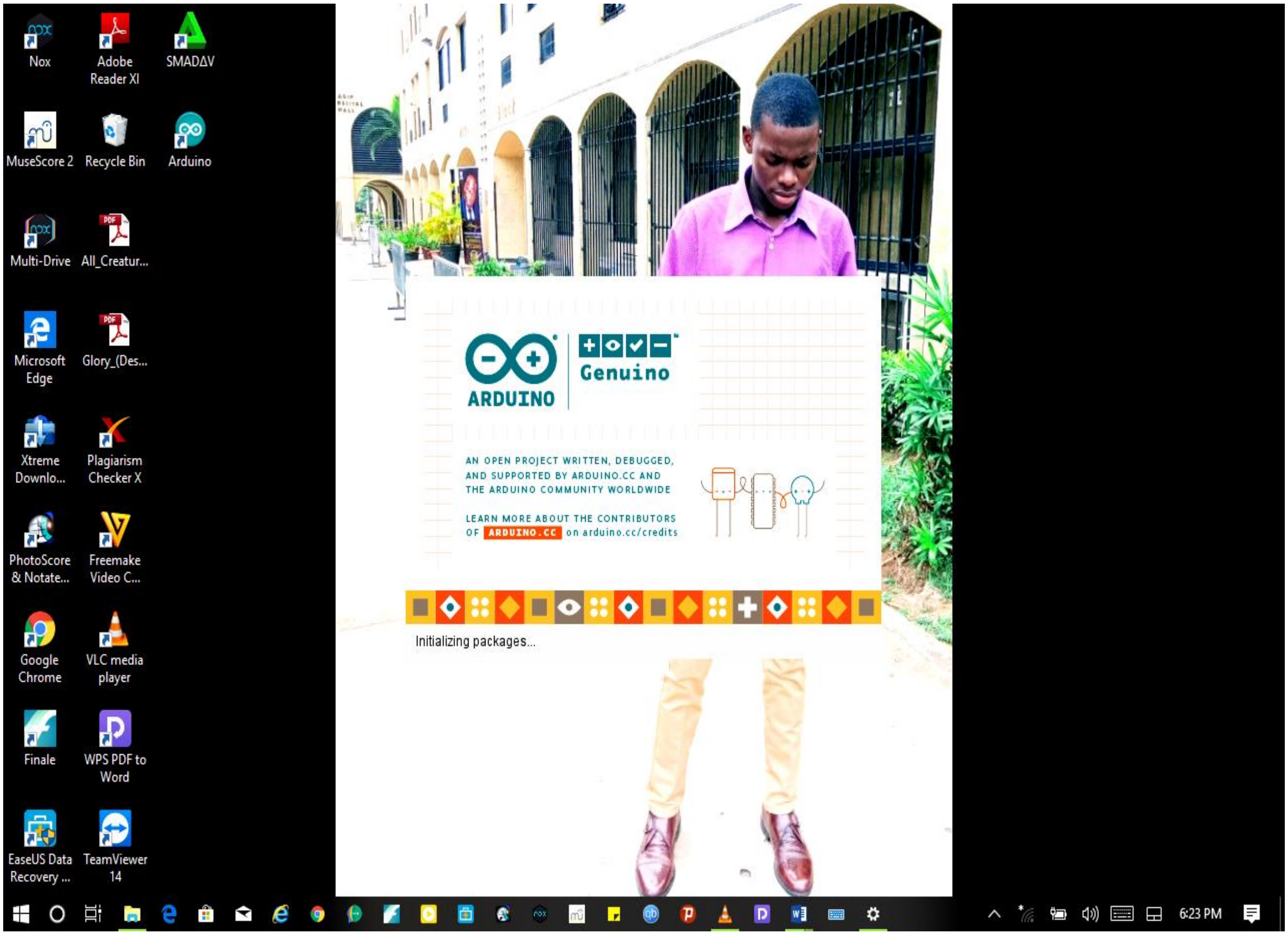

Figure 4.1 Starting the Arduino for the first time after installation.

4.3 Operation of the System

The developed system required the user to have a knowledge of how it worked before he/she could operate it. The user had to be familiar with all the tools used in the development of the system. Before the system was able to work as expected, the Arduino IDE had to be installed on the computer. Afterwards the Arduino Uno microcontroller, the RCWL-0516 proximity sensor, SRD-05VDC-SL-C 5v relay module and the device to be operated by the switch (a light bulb) were connected via a breadboard. The pinout for the modules were outlined below:

The connections between the relay module and the Arduino was listed as follows:

i. GND (ground) pin of the relay was connected to GND (ground) pin on the Arduino for (–) power supply.
ii. IN1 (input 1) pin was connected to digital pin 8 to control the first relay.
iii. IN2 (input 2) pin wasn't connected at all because it wasn't used.
iv. VCC pin of the relay module was connected to 5V pin on the Arduino for (+) power supply.

The RCWL-0516 microwave proximity radar sensor module was connected to the Arduino microcontroller by the brief outline below:

i. GND (ground) pin of the relay was connected to GND (ground) pin on the Arduino for (–) power supply.
ii. OUT (digital output) pin was connected to digital pin 2 to control the first relay.
iii. VCC pin of the relay module was connected to 5V pin on the Arduino for (+) power supply.

NOTE: The normally Open (NO) circuit configuration was used to connect the voltage load device to the relay.

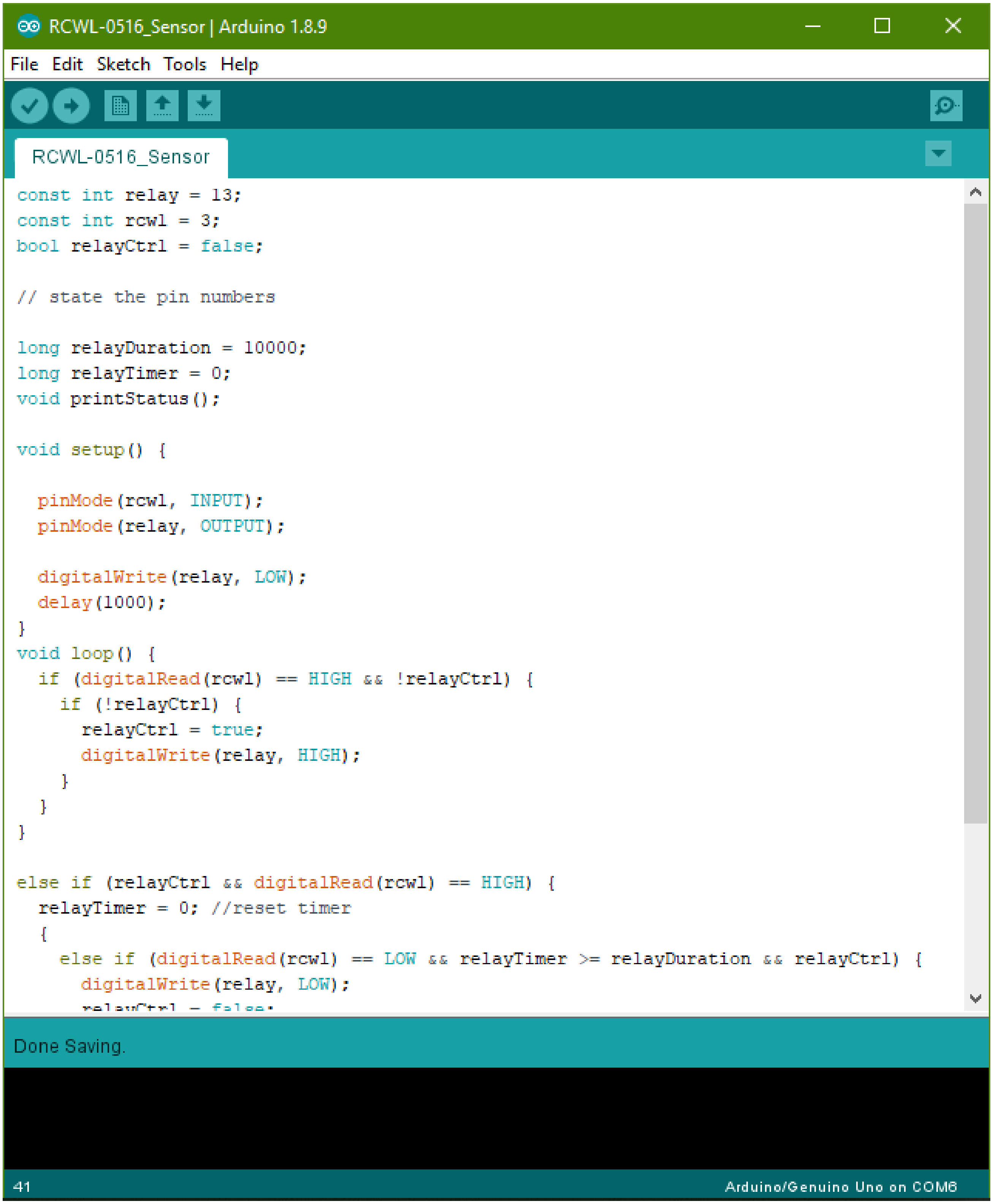

Figure 4.2 The Arduino IDE

4.4 Brief Description of Derived Results

The proposed system was termed a "proximity sensor-controlled switch" because from the term "proximity" which meant nearness or closeness, we could say that this system worked by detecting closeness or nearness from moving bodies towards its direction.

This further entailed that the switch initially turned on or otherwise judging by virtue of open and closed key switching control. However, the relay did the actual making or breaking of the electrical circuit. i.e. even with the actual switch on, without the relay closing the circuit and permitting the flow of electric current through the electric circuit, the whole switching mechanism was obsolete. The relay in this field of play worked only when instructed by the proximity sensor. The proximity sensor detected proximities in form of movements made within its detection range (even the slightest movement around its surveillance axis) and sent packets in form of datagrams to the microcontroller (i.e. Arduino Uno) for cumulative reading of its values in desired file format, further manipulation and documentation if needed. This relay was powered by a 5v power supply, relatively low compared to the high voltage load it was making or breaking. The power supply of the relay had to be isolated from the power supply of the load and that of the microcontroller for safety reasons.

The results derived was that when a body came close to the system, the RCWL-0516 detected motion and then sent a "HIGH" signal to the Arduino microcontroller. The Arduino microcontroller used this "HIGH" signal to tell the 5v relay module to close the electrical circuit and therefore electrical energy was supplied to the device to be controlled by the switch.

4.5 Output of the Proposed System

The output/result obtained from the execution of the proposed system was shown below:

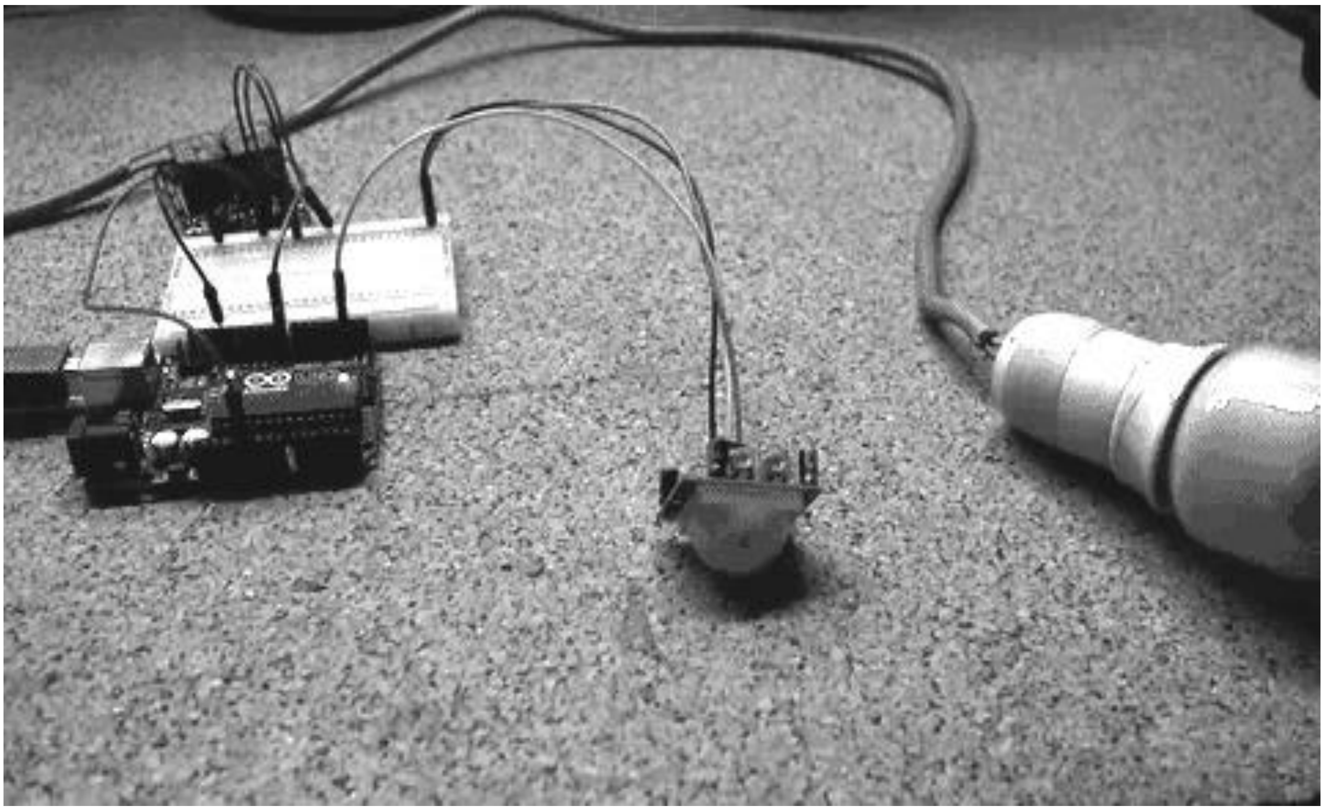

Figure 4.3 System state before motion (proximity) was detected.

Observation: From the above illustrated diagram, it was observed that the electrical device was initially off. This was as a result of the fact that there was no detection by the proximity sensor. i.e no movement was made around the surrounding environment. We can also say that the system was in a passive (inactive) state.

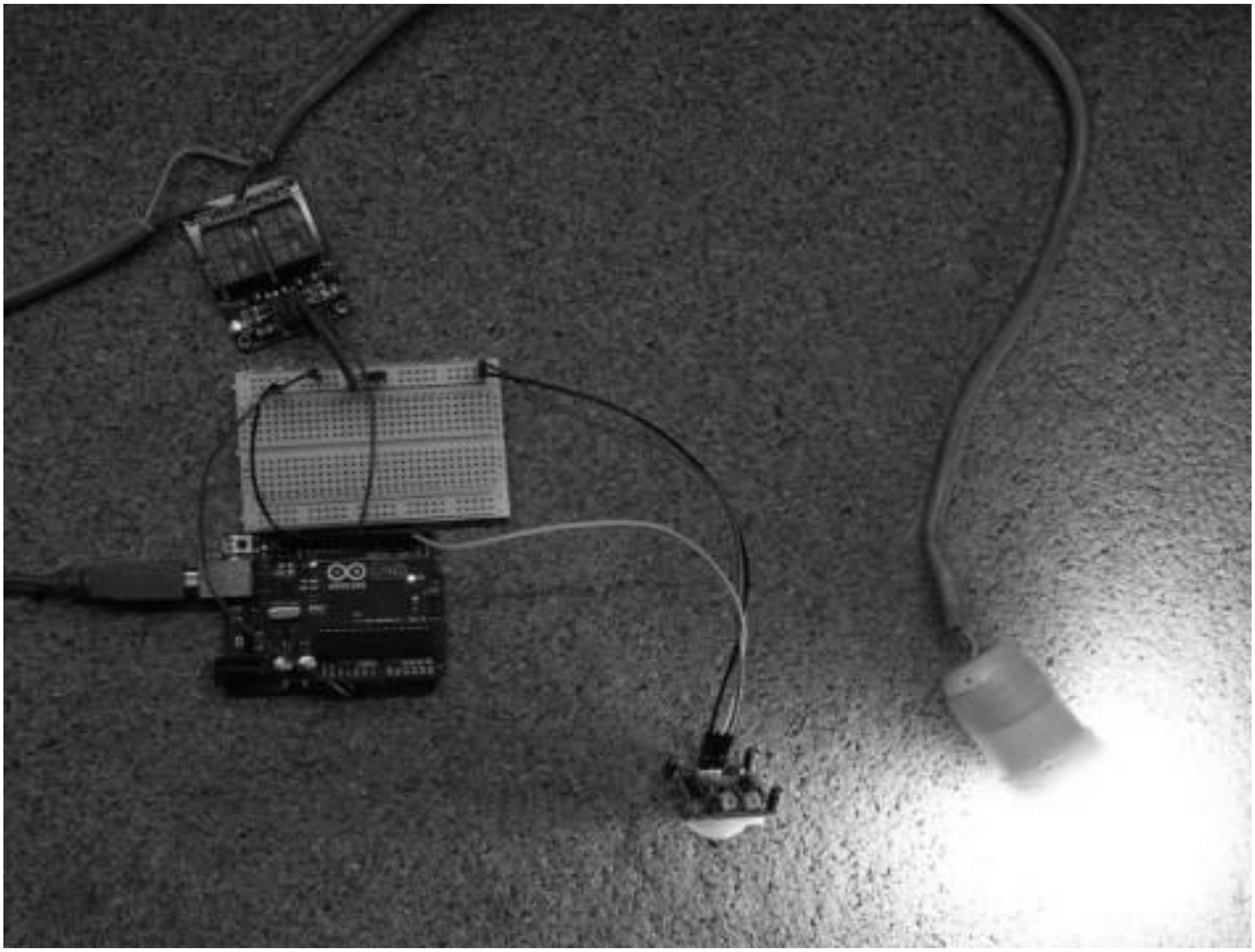

Figure 4.4 System state after motion (proximity) was detected.

Observation: From the above illustrated diagram (Figure 4.8), it was observed that the electrical device was switched on. This justifies the fact that there was detection of motion by the proximity sensor. i.e movement was made around the surrounding environment. We can then say that the system was in a working (active) state.

4.6 Summary of Results Achieved

The first objective focused on designing a motion-controlled switch to detect the movement of persons and objects within a specified area. This was made possible by the RCWL-0516 Microwave Proximity Sensor. The RCWL-0516 operated by sending out doppler waves, i.e. creating a doppler radar and waited for the slightest change in the radar or return wave signal. When this occurred, it sent out a "HIGH" signal to the microcontroller but when no significant change was detected, it remained at a "LOW" signal. This sensor could also be used without the microcontroller but the role of the microcontroller was to enable other diverse functionalities like that associated with this project which involved it working with a relay module.

The second objective dealt with automating the control of electrical appliances using a relay to prevent the excessive drainage of electrical power. This was done by using the Arduino Uno microcontroller to read the input values from the RCWL-0516 microwave proximity sensor. These derived values ("HIGH" or "LOW") were then integrated into the program later written into the Arduino which also included an instruction being sent to a SRD-05VDC-SL-C 5v relay module which remotely opened and closed the circuit of the power source of the equipment or appliance.

CHAPTER FIVE
SUMMARY, RECOMMENDATION AND CONCLUSION

5.1 Summary

Internet of Things (IoT) was born out of the embarkment on the journey to make every day living easier. IoT advanced countless disciplines and sectors most especially the communication sector a great deal. In the process of making an effort to conserve electrical energy, the Proximity Sensor-controlled switch as an automation system technology was developed to manage minor wastage of electrical power by engaging in the effort of turning on or off the electrical circuit of preferred appliances or electrical equipment and devices e.g. Light bulbs, electric fans, air conditioners, Computer systems, etc.

During the course of this project work, the development of a proximity sensor-controlled switch to manage the actuation and automated switching of various electrical circuits was achieved. And by so doing, contributed to the effective conservation of electrical energy in the Mountain Top University (MTU).

Lastly, this project was able to create a motion detection system to detect nearby objects and persons and by so doing, created a stepping stone for security systems development. The device could be easily replaced with a lighting system and buzzer to inform the user on detection of any movement around the specified area.

5.2 Recommendations for Further Research

The system met the desired expectations but would perform better and showcase better features if the following recommendations and suggestions are considered:

The project had the likelihood of not being able to automate the switching heavy duty electrical equipments without the risk of a fire hazard due to the fact that the tools used were light-weight in nature. Yet, it could be upgraded to work with increased voltage load. As a suggestion, the Arduino Uno R3 could be substituted with an Arduino Leonardo Mega2560; the 5v relay can be increased to 24v or 48v relay.

A Passive Infrared (PIR) sensor can be used in place of the RCWL-0516 microwave proximity sensor and a more preferable suggestion will be the use of 3 PIR sensors which will be placed and labelled 1, 2 and 3 respectively. PIR sensor 1 will be the sensor placed on the left hand side, PIR sensor 2 will be placed in the middle and PIR sensor 3 will be the sensor placed at the right hand side. The program written to the Arduino as sketch will entail that when a body moves from left to right past the sensors, the order at which the PIR sensors will detect in the order 1, 2 & 3. But if the body moves from right to left past the sensors, the order of detection will be 3, 2 & 1. The system can be arranged further that when motion is detected from left to right, it means that the person is entering the specified area and the connected electrical appliance to the switch will come on and vice versa. i.e. if there's detection of motion from right to left, it means that the person is exiting the specified area and so therefore the connected electrical appliance will therefore go off. A counter can also be integrated into the system so that when a multiple persons enter the specified area it will increment continuously according to the number and decrement according to the number of persons that leave the specified area. Then when the counter gets to zero, i.e. when there are no persons in the room, the switch will go off as well as all the electrical appliances which is controlled by it.

5.3 Conclusion

Several advances were made towards the scope of this project work by various academicians, scholars and patent inventors even before this particular project work, each with their own pro and cons, strength and weaknesses. This project work also had its limitations. For example, even if there were persons in the radar of the proximity sensor, as far as motion was no longer detected, the device was set to switch off within the short duration of time allocated. i.e. If the switching device was the lighting system of a particular room, the light was set to go off in the room, even with people inside.

In conclusion, from proper analysis and assessment of the designed system it was safely concluded that the system was an efficient, usable and reliable lightweight automated switching system. It worked properly and adequately met the minimum expectations that were required of it initially. The new system expected to conserve electrical energy of light-weight electrical appliances was the proximity sensor-controlled switch designed using IoT technology.

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APPENDICES

```
int sensorPin = 2;          // Set up a rcwl sensor pin
int rcwlState = LOW;
int val = 0;
int relayPin = 8;           //Set up a Relay pin

void setup() {
pinMode(sensorPin, INPUT);
pinMode(relayPin, OUTPUT);
Serial.begin(9600);
}

void loop() {
val = digitalRead(sensorPin);  // read input value
if (val == HIGH) {            // check if the input is HIGH
digitalWrite(relayPin, HIGH);  // turn Relay ON
delay(150);

if (rcwlState == LOW) {
Serial.println("Motion detected!");
rcwlState = HIGH;
}
} else {
digitalWrite(relayPin, LOW); // turn Relay OFF
delay(150);
if (rcwlState == HIGH) {
Serial.println("Motion ended!");
rcwlState = LOW;
}
}
}
```

```
/*
  DigitalReadSerial

  Reads a digital input on pin 2, prints the result to the Serial Monitor

// digital pin 2 has a pushbutton attached to it. Give it a name:
int pushButton = 2;

// the setup routine runs once when you press reset:
void setup() {
  // initialize serial communication at 9600 bits per second:
  Serial.begin(9600);
  // make the pushbutton's pin an input:
  pinMode(pushButton, INPUT);
}

// the loop routine runs over and over again forever:
void loop() {
  // read the input pin:
  int buttonState = digitalRead(pushButton);
  // print out the state of the button:
  Serial.println(buttonState);
  delay(1);        // delay in between reads for stability
}

#include <FileIO.h>

void setup() {
  // Initialize the Bridge and the Serial
  Bridge.begin();
  Serial.begin(9600);
```

```
  FileSystem.begin();

  while (!SerialUSB); // wait for Serial port to connect.
  SerialUSB.println("Filesystem datalogger\n");
}

void loop() {
  // make a string that start with a timestamp for assembling the data to log:
  String dataString;
  dataString += getTimeStamp();
  dataString += " = ";

  // read three sensors and append to the string:
  for (int analogPin = 0; analogPin < 3; analogPin++) {
    int sensor = analogRead(analogPin);
    dataString += String(sensor);
    if (analogPin < 2) {
      dataString += ",";  // separate the values with a comma
    }
  }

  // open the file. note that only one file can be open at a time,
  // so you have to close this one before opening another.
  // The FileSystem card is mounted at the following "/mnt/FileSystema1"
  File dataFile = FileSystem.open("/mnt/sd/datalog.txt", FILE_APPEND);

  // if the file is available, write to it:
  if (dataFile) {
    dataFile.println(dataString);
    dataFile.close();
    // print to the serial port too:
```

```
    SerialUSB.println(dataString);
  }
  // if the file isn't open, pop up an error:
  else {
    SerialUSB.println("error opening datalog.txt");
  }

  delay(15000);

}

// This function return a string with the time stamp
String getTimeStamp() {
  String result;
  Process time;
  time.begin("date");
  time.addParameter("+%D-%T");  // parameters: D for the complete date mm/dd/yy
  //       T for the time hh:mm:ss
  time.run();  // run the command

  // read the output of the command
  while (time.available() > 0) {
    char c = time.read();
    if (c != '\n') {
      result += c;
    }
  }

  return result;
}
```