DEVELOPMENT OF AN ARDUINO BASED COST EFFECTIVE SMART HOME AUTOMATION SYSTEM

BY

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CPE/12/0890

A Project Submitted to the Department of Computer Engineering,

Faculty of Engineering,

Federal University, Oye- Ekiti,

Ekiti, Nigeria.

In partial fulfillment of the requirements for the degree of Bachelor of Engineering (B.Eng.) in Computer Engineering,

November, 2017

CERTIFICATION

This project with the title Development of an Arduino Based Cost Effective Smart Home System submitted by Oladepo Oladimeji has satisfied the regulations governing the award of degree of Bachelor of Engineering (B.Eng.) Federal University Oye-Ekiti, Ekiti.

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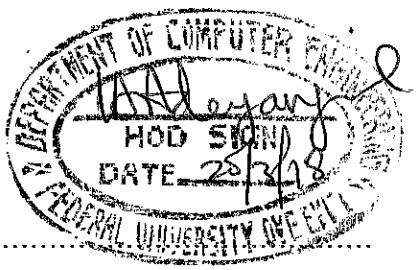
Dr. A.S Falohun Date

Supervisor



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Dr. I.A. Adeyanju Date

Ag. Head of Department

DECLARATION

I, Oladepo Oladimeji hereby declare that this project work is the result of my personal effort under the supervision of Engr. Dr. A.S. Falohun of the Department of Computer Engineering, Federal University Oye-Ekiti, Ekiti State, as part of the requirements for the award of Bachelor Degree in Computer Engineering, and has not been submitted elsewhere for this purpose. All sources of information are explicitly acknowledged by means of reference.

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OLADEPO OLADIMEJI DATE

CPE/12/0890

DEDICATION

This report is dedicated to every unique individual who has an unquenchable thirst for knowledge and has dedicated their lives to an endless drive in the pursuit for a better path for humanity.

ACKNOWLEDGEMENTS

Firstly, I acknowledge the Most High God for his grace, mercy and provision throughout my life and stay at Federal University Oye-Ekiti.

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ABSTRACT

Nowadays, most of the conventional home automation systems are designed for special purposes but this system proposes an all-in-one general purpose home automation system that can be easily be implemented in new and existing homes. The aim is to develop a reliable, compact, fast and low cost smart home automation system, based on Arduino Uno (microcontroller).

Various devices such as LEDs, DC Servo motors, passive infrared sensor have been incorporated in the system to demonstrate the feasibility, reliability and quick operation of the proposed smart home system. Arduino uno microcontroller provides the needed processing power for driving the aforementioned devices. Proteaus design suite together with fritzing was used for the system design and simulation.

The system developed was tested and it is capable of running successfully and performing the desired operations. It is shown to be efficient and yet a cost effective solution for basic needs in homes, in terms of handling repetitive tasks such as switching of security lights and efficient power management and also security of homes.

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LIST OF ACRONYMS

I.R	INFRARED RADIATION
GND	GROUND
PVC	PLASTIC POLYVINYL CHLORIDE
LED	LIGHT EMITTING DIODE
RF	RADIO FREQUENCY
LCD	LIQUID CRYSTAL DISPLAY
G.U.I	GRAPHICS USER INTERFACE
M.C	MICROCONTROLLER

CHAPTER ONE

INTRODUCTION

1.1 Preamble

As today's generation is very busy, individuals sometimes may forget to switch off various home appliances or not sure about whether the devices are on or off. Sometimes, it is also desirable for individuals to turn on few devices such as air conditioners, few lights etc. to get a comfortable, pleasant atmosphere immediately after going back home. Person with physical disability may also wish to control the devices automatically; it is now possible to practically implement all the desirable functions in a home automation system (Gunge, 2016).

Home automation system is the use of sensors and control system to reduce the human labor. The rapid growth of technology influences the use microcontroller to remotely control home appliances. An automated device has ability to work with versatility, diligence and with lowest error rate. The idea of home automation system is a significant issue for researchers and home appliances' companies. Automation is the backbone of modern industries; it is the key to global economic growth as it allows for increasing productivity and accuracy by cutting out the human intervention while reducing costs. Home automation is the extension of industrial process automation to households' appliances. Among others home automation may include the remote control of lights (centralized or individual), air conditioning, security etc. Automation system not only helps to decrease the human labor but it also saves time and energy. Early home automation systems were used in labor saving machines but nowadays its main objective is provide facilities to elderly and handicapped people to perform their daily routine tasks and control the home appliances remotely. In wireless based home

automation system different type of technologies such as ZigBee , Z-Wave, Global System for Mobile (GSM), General Packet Radio Service (GPRS), Infrared, wireless fidelity (Wi-Fi) and Bluetooth are used, each technology has their own pros and cons plus they add to the overall cost of the system (Mukendi & Adonis, 2008).

The proposed method presents the design and implementation of a robust, low cost and user friendly home automation system using arduino microcontroller. The design of proposed method is based on Arduino board, sensors that are systematically placed in various part of the home (Wu & lin, 2001.). This method has ability to carry out repetitive task in our everyday lives. Nowadays most of conventional home automation systems are designed for elderly, handicapped people or for any special purpose. The proposed method is not only suitable for elderly and handicapped people but it also provides a general purpose home automation system, which can easily be implemented in existing home (Elkamchouchi & Elshafee, 2012).

1.2 Various Task in Homes

The various tasks that have been identified to be most common and reoccurring in every home and that will significantly reduce human effort and possibly bills include:

i. Switching of security lights
ii. Automatic door opening
iii. Cutting out power supply to appliances when no one is at home
iv. Water level indicator FOR control when water tanks are filled.
v. Automatic fan control that relies on room temperature.
vi. Automatic wetting of flowers and plants by using soil moisture sensor.

1.3 Statement of Problem

Many tasks in our day to day lives are repetitive and often time involves human effort to handle. From the switching "on" of security light at night and the switching "off" in the day time, to gate/door opening and closing when there is need for it, control of appliances, water tank pumping indicator etc. On many occasions, humans tend to be forgetful, negligent or don't take cognizance of the things around us that may actually be hazardous or prove costly if not attended to promptly. The result of these human factors include hike in energy bills due to high energy consumption and unnecessary use of home appliances which might reduce the service life of the home appliances all of which will cost a lot of money to rectify.

1.4 Aim and Objectives

The aim of this project is to design an automated cost-effective smart home system using arduino microcontroller and sensors.

The specific objectives are to:

i. Design a smart home system for the automation of various parts a house based on the use of cheap sensors and actuators.
ii. Implement the design of the smart home system using a prototype
iii. Test the effectiveness and efficiency of the developed system.

1.5 Scope of Study

The project will develop a prototype of an ultra-low budget smart home system based on an arduino microcontroller. The smart home system will make use of several sensors that are placed in carefully selected locations in the house to automate the repetitive task in a house which include automatic security light and smart energy saver.

1.6 Significance of Study

The Smart home systems are used in:

i. Monitoring the lightning in a home which includes the interior of the house and the security lights.

ii. Reduced energy consumption by automatically shutting down the electrical sockets when no one is at home.

1.7 Methods of Study

The methods to be used in achieving this project will include the following:

i. Constant review of relevant literature in the library and online resources related to smart home automation systems

ii. Interaction with experts in sensor networks.

iii. Methods of integrating many sensors together on the microcontroller to form a compound sensor network that will implement the task.

iv. Design of the smart home system prototype using arduino microcontroller.

v. A house will be emulated using a do-it-yourself doll house (prototype).

vi. Sensors will be placed at remote places in the doll house.

vii. Implementation of the system using the proposed smart home system.

CHAPTER TWO

LITERATURE REVIEW

2.1 Brief History of Smart Home

Most of homes use the traditional lighting system where we have a switch to control the lighting. Most of people are habituated towards leaving their homes without switching the lights, fan, air conditioner etc. which leads to unnecessary consumption of energy for home owners and paying huge amount of bill from their budget. Some of the lighting systems have come with remote system towards controlling the lighting and fan similar to air conditioner which is being used in homes. But still there is challenge towards leaving the lights and fans unattended when no one is the room (Gunge, 2016).

The experimental results from a survey (by U.S power consumption management) showed that we can reduce energy bills to the extent of 50% if the electrical appliances are switched OFF promptly when not in use.

The concept of Smart Home appeared at the beginning of the 20th century, long before and independently of the revolution of information and communication technologies. Nevertheless, the Smart Home vision only became technically feasible with the spread of the recent developments in information and communication technologies related to computer networks, embedded systems, and artificial intelligence, and thus it became a market reality starting with the end of the 20st century (ElShafee, 2012).

The concept of Smart Home is closely related to the more established area of Home Automation, also known as Domotics, as well as to more recent areas of Ambient Intelligence and Smart Environments. The concept recently evolved to the idea of Smart Home Environments (SHE) hereafter. SHE are envisioned as being able to exhibit

various forms of artificial intelligence by enhancing traditional Home Automation systems with new smart functions addressing diverse high-level goals of well-being like increasing comfort, reducing operational costs, and guaranteeing safety and security for the house holders (Asadullah and Raza, 2017)

2.2 Automation

Automation is the technology by which a process or procedure is accomplished without human assistance. Automation technology is a crossover discipline that uses knowledge and scientific methods from numerous other technical sciences. In today's fast-moving, highly competitive industrial world, a company must be flexible, cost effective and efficient if it wishes to survive. In the process and manufacturing industries, this has resulted in a great demand for industrial control systems/ automation in order to streamline operations in terms of speed, reliability and product output. Automation plays an increasingly important role in the world economy and in daily experience (Groover, 2008).

Automation is the use of control systems and information technologies to reduce the need for human work in the production of goods and services. In the scope of industrialization, automation is a step beyond mechanization. Whereas mechanization provided human operators with machinery to assist them with the muscular requirements of work, automation greatly decreases the need for human sensory and mental requirements as well (Groover, 2008).

Automation Control System

Automation Control System - system that is able to control a process with minimal human assistance or without manual and have the ability to initiate, adjust action show

or measures the variables in the process and stop the process in order to obtain the desired output (Mukendi & Adonis, 2008).

The Main Advantages of Automation are:

i. Replacing human operators in tasks that involve hard physical work.

ii. Replacing humans in tasks done in dangerous environments (i.e. fire, space, volcanoes, nuclear facilities, underwater, etc.)

iii. Performing tasks that are beyond human capabilities of size, weight, speed, endurance, etc.

iv. Economy improvement: Automation may improve in economy of enterprises, society or most of humanity. For example, when an enterprise invests in automation, technology recovers its investment; or when a state or country increases its income due to automation like Germany or Japan in the 20th Century.

v. Reduces operation time and work handling time significantly.

The Main Disadvantages of Automation are:

i. Unemployment rate increases due to machines replacing humans and putting those humans out of their jobs.

ii. Technical Limitation: Current technology is unable to automate all the desired tasks.

iii. Security Threats/Vulnerability: An automated system may have limited level of intelligence; hence it is most likely susceptible to commit error.

iv. Unpredictable development costs: The research and development cost of automating a process may exceed the cost saved by the automation itself.

v. High initial cost: The automation of a new product or plant requires a huge initial investment in comparison with the unit cost of the product, although the cost of automation is spread in many product batches of things. (Groover, 2008).

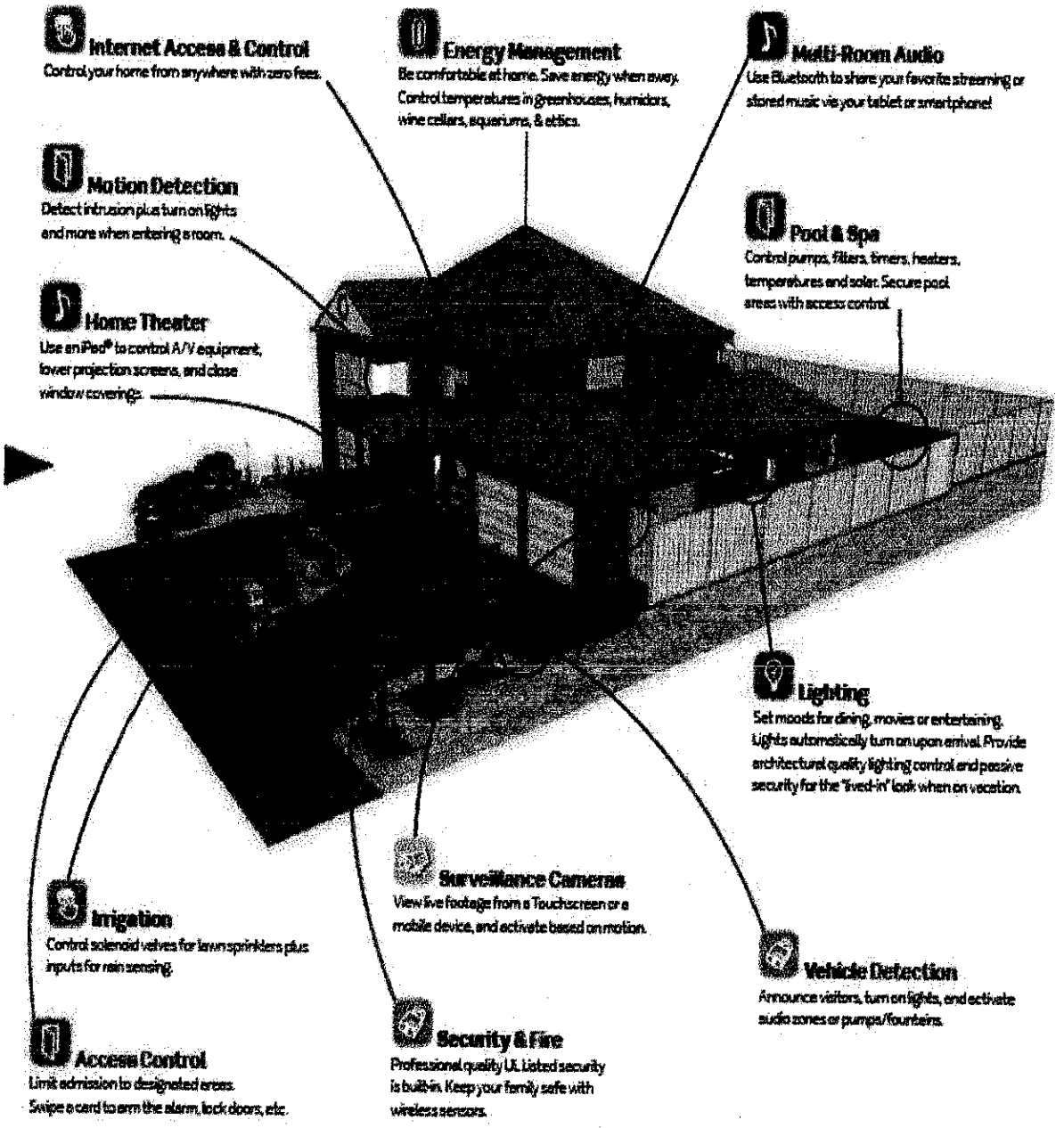

Figure 2.1: Overview of smart home (online source: www.hai.com/overview.htm)

2.3 Overview of Home Automation Systems

A home automation system is a channel by which homeowners and occupants have remote control over different types of electrical and electronics appliances in their home. The home automation system is the use of robotics and computer technologies to control every aspect of the home including doors and gates. Energy saving is the advantage that a home automation system gives to all its clients and especially forgetful ones, in that they can now track energy usage at home or while being a way to ensure that unnecessary appliances are turned off as needed to reduce energy consumption. Smart home is a very promising and interesting area, which is providing us various benefits such as added comfort, greater safety and security, a more efficient use of energy and other resources; thus contributing to a significant amount of power saving. This project application domain is very useful and will be utilized massively in the future as it offers a powerful means for helping and supporting special needs of the elderly and people with disabilities (Vaishnavi, 2016). Nowadays the home automation market aims to a specific target, the new buildings. Infinite solutions already exist to make a smart home, of course, the smart home market is not new, but all the present products have two points in common: they are invasive and expensive. People building a new house do not care about the invasion, and compared to the total price of the dwelling, the automated system seems even cheaper (Golzar & Tajozzakerino, 2010).

2.4 Types of Home Automation

Home Security Automation

Protect home owners' lives and property around the clock. Example include burglar and fire detection; which is the protection of homes from Intrusion, smoke, fire, carbon monoxide, water, vehicle presence and other hazards are detected by either wired or

wireless sensors. Apps provide control via smartphone or tablet (Piyare and Tazil, 2011).

Security sensors also act as the eyes and ears of the home. Safety, energy management, and entertainment devices can be automated by event like door opening or motion and schedule like time or day. For additional security, home owners can integrate wireless vehicle detection, wireless door locks, surveillance cameras, telephone back-up, and hard-wired access control.

Home Surveillance Automation

Home surveillance/monitoring systems are widely used nowadays. An intelligent surveillance system can provide multiple functions for uses. Nowadays, many intelligent applications with multiple functions are becoming part of our daily lives due to the developments in networking, computing, and communications technologies (Sun, 2010). Surveillance systems are utilized in many places for public & private security, such as banks, supermarkets, and environments which are hazardous or inaccessible for human beings (for example, in environments which with poisonous gases, or very low or high temperatures).

Since computers and network are widespread, many new network based applications are appearing in our homes. Although home surveillance systems are used in a small fraction of homes, the number of people deploying such systems is gradually increasing as more and more functions are implemented by such a system. While initially such systems provided only entry alarms (to deter theft) or smoke & fire alarms (to automatically summon the fire department), later systems incorporated temperature

Measurement, detectors for water leaks, etc. These systems help people manage their

homes more easily, provide improved security, and enable the home owner to know

What happens inside or around their home (Zixuan, 2016)?

A home surveillance/monitoring system may include video cameras, terminals, sensors, actuators, and severs. More generally, such a system can be used for monitoring or controlling devices. Typically the network transfers data from sensors to a server, from which the user can request information. Similarly the user can send commands via the server to sensors and actuators to control devices. These systems are increasingly connected via a gateway (with firewall) to the internet. As a result home owners can both monitor their homes and control devices in their homes via the internet or other IP network (Kaufman, Perlman, & Speciner, 1995).

Surveillance systems based on IP networks have become mainstream products in recent years. Large numbers of images and other forms of data can be transmitted in real time through the internet or intranet. Moreover, the surveillance system has gradually evolved from only the traditional security monitoring functions to become an intelligent management system. Compared to analog surveillance system, a networked surveillance system is more flexible, reliable, and lower in cost. Because of the application-centric design of these in networked surveillance system, new software and hardware can easily be added according to the user's specific needs.

Surveillance system keeps a watchful eye around the home, even when the home owners are not at home. IP or analog surveillance cameras are used to monitor the homes and send still video frames are emailed or uploaded to an FTP site when motion is detected. Most surveillance automation system have a built-in dedicated touchscreen, swipe through your list of cameras, select a camera to view a thumbnail and click the

thumbnail for full screen viewing. They are basically used to view live footage of nurseries, entrances, driveways, boat docks, and pool areas from anywhere in the world. Check up on a relative or pet from your smartphone or tablet.

Home Access Control Automation

Automatic entrance/exit door control is widely used in public places such as grocery stores, businesses, transportation stations, airports, and wholesale department stores to eliminate the need of manually opening and closing actions. Contemporary sensor-based automatic door control technologies include infrared, ultrasonic/radio, or other wireless sensing methods (John, 2014). The first can be further divided into active and passive approaches. The active process emits infrared signals from the controller and captures the reflected signals to determine if there is any object close to the door. This approach is accurate and capable of identifying the position and the speed of the object but its high cost has made it less popular. The passive approach detects the infrared signals radiated by people and is the most widely used for being simple, effective, and low cost. The ultrasonic/radio approach, on the other hand, emits ultrasonic or radio waves to scan the environment and analyzes the returned signals for door access control. Although these techniques are all successful in detecting objects, they are not capable of understanding the type and the intention of the objects. For instance, a puppy or a passing pedestrian may accidentally trigger the door and cause a false opening action. Frequent false action is not only annoying, and results in air conditioning energy waste, but also reduces equipment lifetime. This calls for the need of an automatic door control system based on the detection and intention analysis of people. Door control is based on the confirmation that the detected object is indeed a human and the corresponding movement trajectory also indicates that he/she has the intention to go through the

entrance. Furthermore, an infrared function has been added to prevent people from being trapped by the door before they leave the passage.

Access control limits admission to designated areas using sensors and actuators. Restriction of gate and door access using card reader to guard's wine cellars, outbuildings and pool areas (David, Chima, Ugochukwu, & Obinna, 2015). The use of infrared remote control to unlock a door, or to activate pathway lighting, turns off the alarm, and adjusts temperatures.

Home Energy Management Automation

By intelligently controlling the lighting and heating throughout a home it is possible to make significant cost and energy savings and this is also the case with wired and wireless automation. For instance, central heating systems, instead of heating the whole house, can be split into different zones so that rooms or areas are warmed as and when they are required. In the same way, lighting systems can be controlled so that the right light output is delivered when and where it is needed (Mukendi and Adonis, 2015).

This keeps the home comfortable while saving money on energy use. By automating temperatures, water heaters, fountains, and pumps based on time or occupancy, you can reduce energy expenditures. The thermostat learns heating and cooling patterns for maximum efficiency and comfort. ZigBee wireless modules manage energy use in high wattage loads like pool pumps and electric water heaters. Utilize temperature and humidity sensors for attics, garages, greenhouses, basements, wine cellars, coolers, pools, and spas. Use a built-in touchscreen, smartphone or tablet to access temperature and humidity set points for dozens of thermostats at any time. Prior to arrival, turn up the heat at your mountain lodge or activate pool fountains at your beach house. Come

home every night to a cozy and conveniently climate controlled environment (Santos-P′erez, Gonz′alez-Parada, & Garc′ıa, 2015).

Home Lighting Automation

This is used to set elegant lighting throughout the home to enhance its security and beauty. Enhance the enjoyment and value of the home, improve safety, and contribute to savings on energy bills. Automatic lighting is done by schedule, motion detection, door openings, sunrise, sunset, alarm activation, and more.

2.5 Proposed System Description

The proposed system has two main parts hardware and software. The hardware part consists of several hardware components including Arduino board and sensor modules. Software part consists of Arduino Integrated Development Environment (IDE). Ultrasonic, LDR, PIR and soil moisture sensor are also used in this method to provide more ease and facilities to the home users.

2.5.1 Hardware Components

Several hardware components incorporated in this work include:

2.5.1.0 Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter. "Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno and version 1.0 will be the reference versions of Arduno, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform. The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

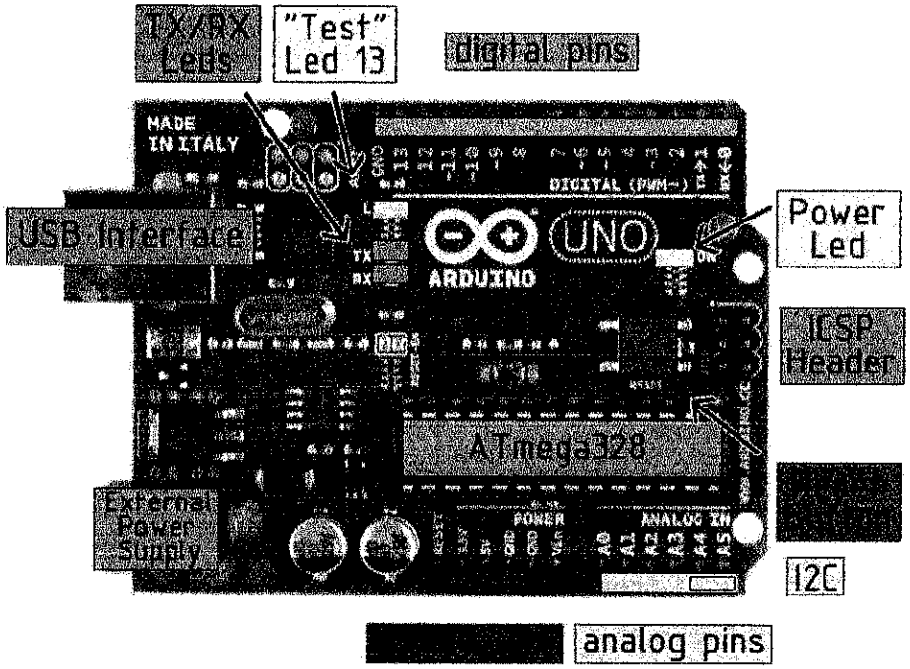

Figure 2.2: Arduino Uno Board (**online source: www.arduino.cc/overview/uno.htm**)

2.5.1.1 Light Dependent Resistor (LDR)

Light dependent resistor also known as a LDR, photo resistor, photoconductor or photocell, is a resistor whose resistance increases or decreases depending on the amount of light intensity. LDRs (Light Dependent Resistors) are a very useful tool in a light/dark circuits. An LDR can have a variety of resistance and functions. For example it can be used to turn on a light when the LDR is in darkness or to turn off a light when the LDR is in light. It can also work the other way around so when the LDR is in light it turns on the circuit and when it's in darkness the resistance increase and disrupts the circuit. The way an LDR works is that they are made of many semi-conductive materials with high resistance. The reason they have a high resistance is that are very few electrons that are free and able to move because they are held in a crystal lattice and are unable to move. When light falls on the semi conductive material it absorbs the light

photons and the energy is transferred to the electrons, which allow them to break free from the crystal lattice and conduct electricity and lower the resistance of the LDR.

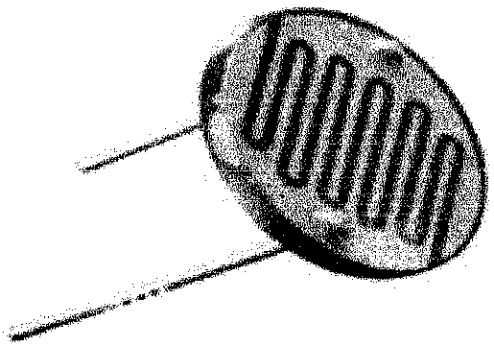

Figure 2.3: Light dependent resistor (online source: www.sensors.org/ldr.htm)

2.5.1.2 PIR

The term PIR is the short form of the Passive Infra-Red. The term "passive" indicates that the sensor does not actively take part in the process, whichmeans, it does not emit the referred IR signals itself, rather passively detects the infrared radiationscoming from the human body in the surrounding area.

PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensors range. They are small, inexpensive, low-power, easy to use and don't wear out. For that reason they are commonly found in appliances and gadgets used in homes or businesses. They are often referred to as PIR, "Passive Infrared", "Pyroelectric", or "IR motion" sensors.

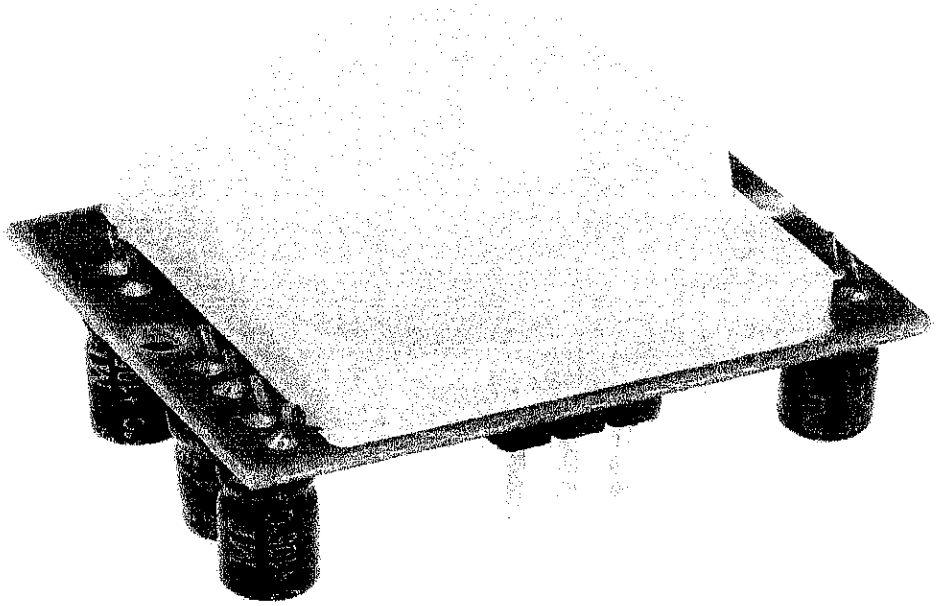

Figure 2.4: PIR

2.5.1.3 Ultrasonic Sensor

An Ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object. Since it is known that sound travels through air at about 344 m/s (1129 ft/s), you can take the time for the sound wave to return and multiply it by 344 meters (or 1129 feet) to find the total round-trip distance of the sound wave. Round-trip means that the sound wave travelled 2 times the distance to the object before it was detected by the sensor; it

includes the 'trip' from the sonar sensor to the object AND the 'trip' from the object to the Ultrasonic sensor (after the sound wave bounced off the object). To find the distance to the object, simply divide the round-trip distance in half. It is important to understand that some objects might not be detected by ultrasonic sensors. This is because some objects are shaped or positioned in such a way that the sound wave bounces off the object, but are deflected away from the Ultrasonic sensor. It is also possible for the object to be too small to reflect enough of the sound wave back to the sensor to be detected. Other objects can absorb the sound wave all together (cloth, carpeting, etc), which means that there is no way for the sensor to detect them accurately. These are important factors to consider when designing and programming a robot using an ultrasonic sensor.

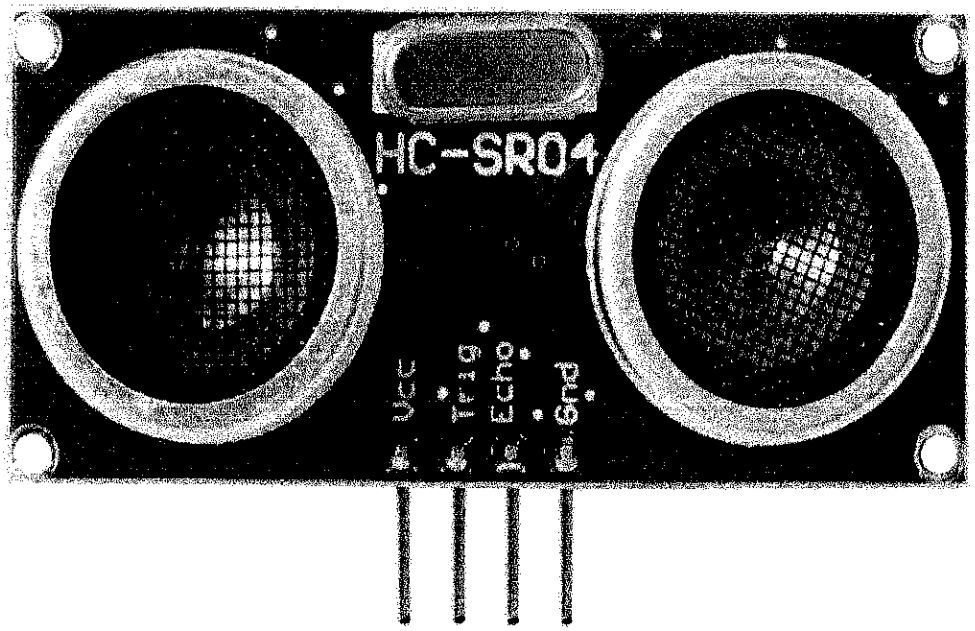

Figure 2.5: Ultrasonic sensor module (online source: www.mahai.com/007mt.htm)

2.5.1.4 Buzzer

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical, or piezoelectric. Typical uses of buzzers and beepers include alarm devices, timers, and confirmation of user input such as a mouse click or keystroke.

2.5.1.5 L298N Dual h-bridge motor controller module

H-Bridge's are typically used in controlling motor speed and direction, but can be used for other projects such as driving the brightness of certain lighting projects such as high powered LED arrays. An H-Bridge is a circuit that can drive a current in either polarity and be controlled by Pulse Width Modulation (PWM). Pulse Width Modulation is a means in controlling the duration of an electronic pulse. In motors try to imagine the brush as a water wheel and electrons as the flowing droplets of water. The voltage would be the water flowing over the wheel at a constant rate, the more water flowing the higher the voltage. Motors are rated at certain voltages and can be damaged if the voltage is applied to heavily or if it is dropped quickly to slow the motor down. Thus PWM, take the water wheel analogy and think of the water hitting it in pulses but at a constant flow. The longer the pulses the faster the wheel will turn, the shorter the pulses, the slower the water wheel will turn. Motors will last much longer and be more reliable if controlled through PWM.

2.5.1.6 Temperature Sensor (Lm 35)

The LM35 series are precision integrated-circuit temperature devices with an output voltage linearly-proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient

Centigrade scaling. The LM35 device does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full −55°C to 150°C temperature range. Lower cost is assured by trimming and calibration at the wafer level. The low-output impedance, linear output, and precise inherent calibration of the LM35 device makes interfacing to readout or control circuitry especially easy. The device is used with single power supplies, or with plus and minus supplies. As the LM35 device draws only 60 μA from the supply, it has very low self-heating of less than 0.1°C in still air.

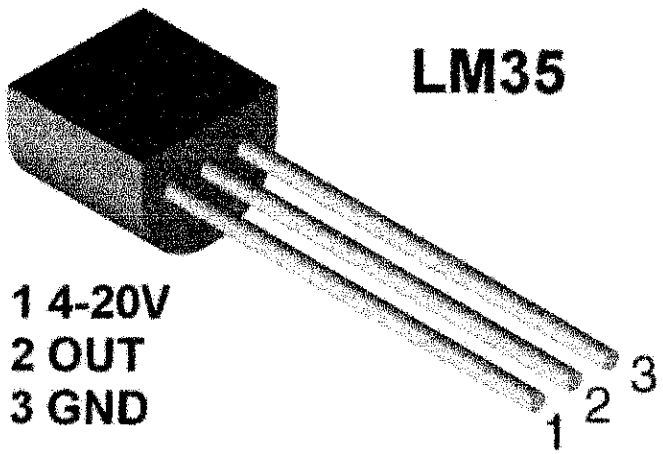

Figure 2.6: Temperature sensor (LM35) (Cogkun & Ardam, 1998)

2.5.1.7 Servo Motor

A servo motor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated

controller, often a dedicated module designed specifically for use with servomotors. Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system. Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing. A servomotor is a closed-loop servomechanism that uses position feedback to control its motion and final position. The input to its control is a signal (either analogue or digital) representing the position commanded for the output shaft. The motor is paired with some type of encoder to provide position and speed feedback. In the simplest case, only the position is measured. The measured position of the output is compared to the command position, the external input to the controller. If the output position differs from that required, an error signal is generated which then causes the motor to rotate in either direction, as needed to bring the output shaft to the appropriate position. As the positions approach, the error signal reduces to zero and the motor stops.

The very simplest servomotors use position-only sensing via a potentiometer and bang-bang control of their motor; the motor always rotates at full speed (or is stopped). This type of servomotor is not widely used in industrial motion control, but it forms the basis of the simple and cheap servos used for radio-controlled models. More sophisticated servomotors use optical rotary encoders to measure the speed of the output shaft and a variable-speed drive to control the motor speed. Both of these enhancements, usually in combination with a PID control algorithm, allow the servomotor to be brought to its commanded position more quickly and more precisely, with less overshooting.

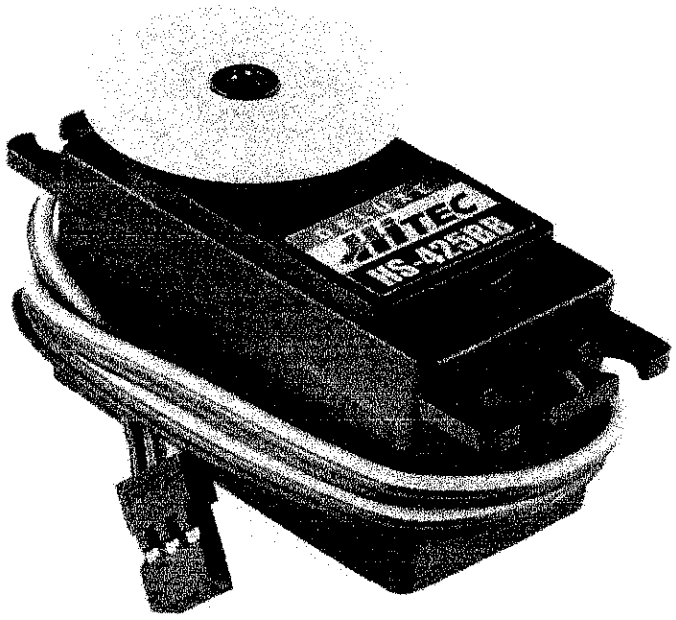

Figure 2.7: Servo motor (Cogkun & Ardam, 1998)

2.5.1.8 Dc Motor

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor.

DC motors were the first type widely used, since they could be powered from existing direct-current lighting power distribution systems. A DC motor's speed can be controlled over a wide range, using either a variable supply voltage or by changing the strength of current in its field windings. Small DC motors are used in tools, toys, and appliances. The universal motor can operate on direct current but is a lightweight motor used for portable power tools and appliances. Larger DC motors are used in propulsion

of electric vehicles, elevator and hoists, or in drives for steel rolling mills. The advent of power electronics has made replacement of DC motors with AC motors possible in many applications.

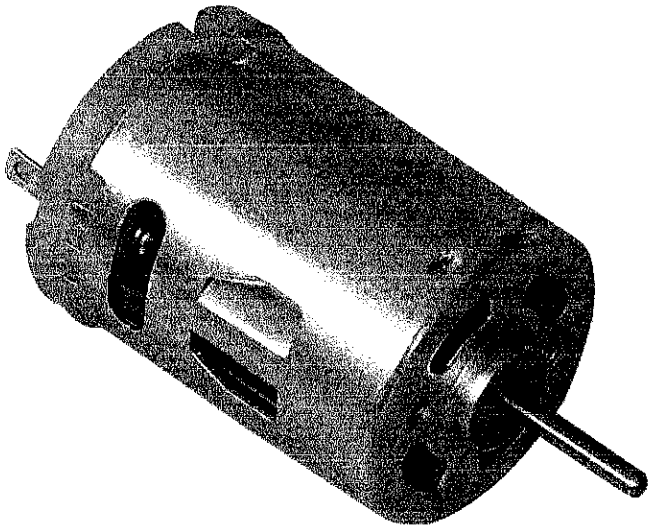

Figure 2.8: DC MOTOR (Cogkun & Ardam, 1998)

2.5.1.9 LED

A light-emitting diode (LED) is a two-lead semiconductor light source. It is a p–n junction diode that emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor. LEDs are typically small (less than 1 mm^2) and integrated optical components may be used to shape the radiation pattern.

Early LEDs were often used as indicator lamps for electronic devices, replacing small incandescent bulbs. They were soon packaged into numeric readouts in the form of seven-segment displays and were commonly seen in digital clocks. Recent developments have produced LEDs suitable for environmental and task lighting. LEDs have LED to new displays and sensors, while their high switching rates are useful in advanced communications technology.

LEDs have many advantages over incandescent light sources, including lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster switching. Light-emitting diodes are used in applications as diverse as aviation lighting, automotive headlamps, advertising, general lighting, traffic signals, camera flashes, and lighted wallpaper. They are also significantly more energy efficient and, arguably, have fewer environmental concerns linked to their disposal.

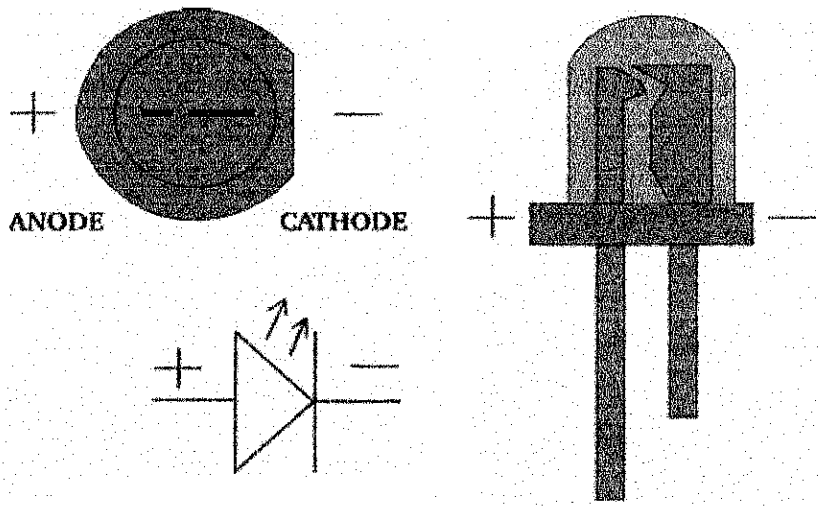

Figure 2.9: light emitting diode (Cogkun & Ardam, 1998)

2.5.1.10 Jumper Wires

A jump wire (also known as jumper, jumper wire, jumper cable, DuPont wire, or DuPont cable – named for one manufacturer of them) is an electrical wire or group of them in a cable with a connector or pin at each end (or sometimes without them – simply "tinned"), which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering.

Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment.

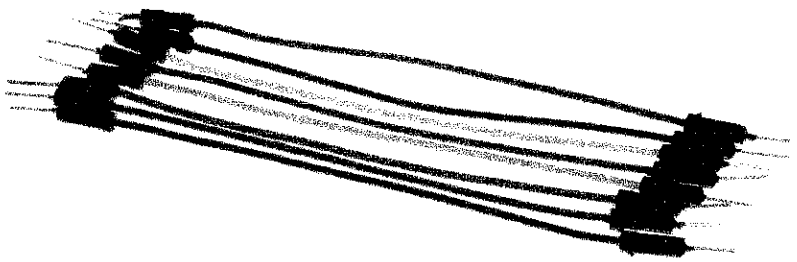

Figure 2.10: Jumper/connecting wire(online source: www.wikipedia.com/cables.htm)

2.5.1.11 Power Source

A 9 volt battery is used to power the arduino microcontroller and a separate 9 volt battery for the automatic security light.

2.5.2 Software Components

The various software used during the cause of this project include:

2.5.2.1 Arduino IDE

IDE stands for Integrated Development environment; entire programming for proposed system is done in Arduino IDE tool. Baud rate is set to 9600 bits per second for serial communication between Arduino board and smartphone.

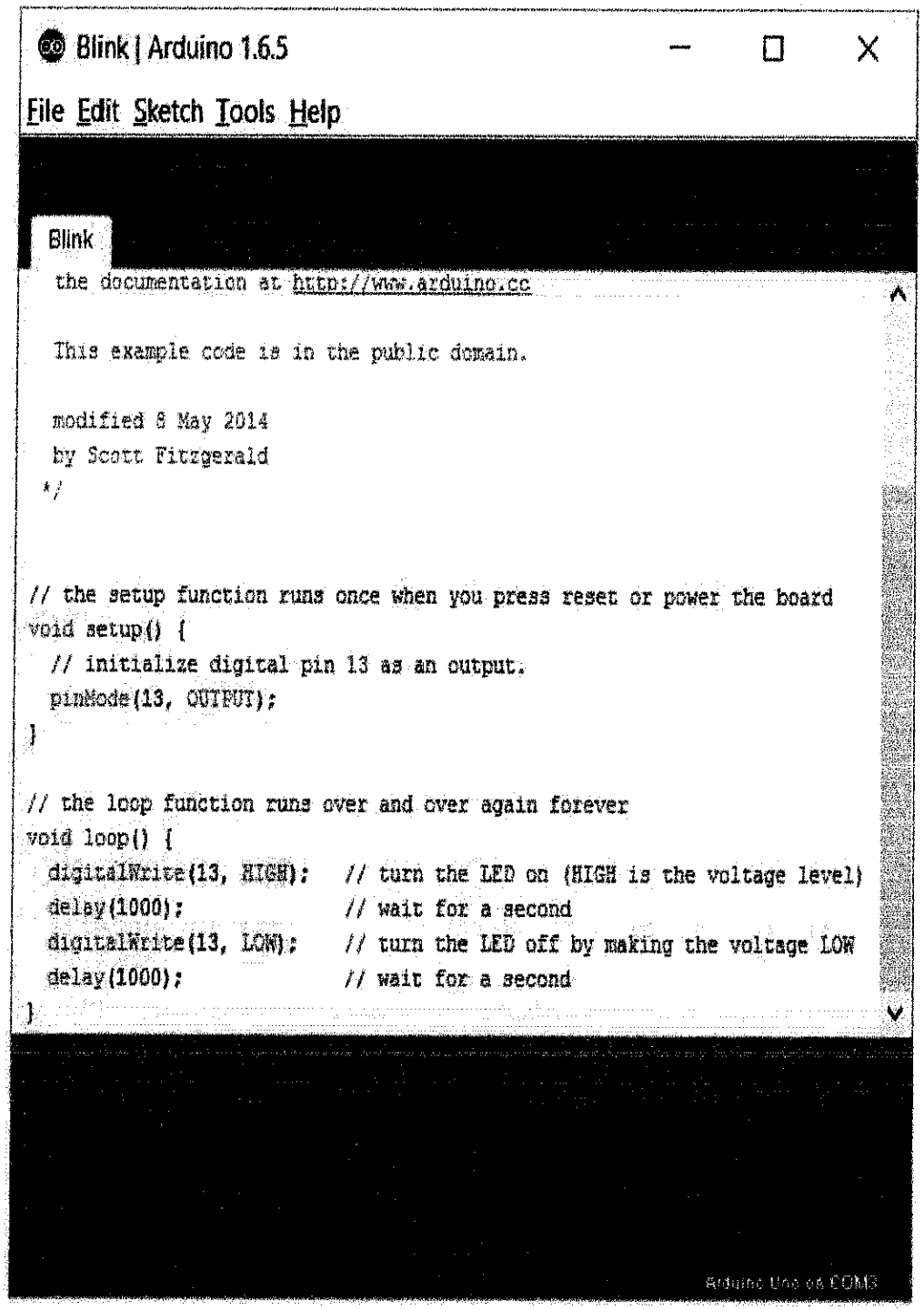

Figure 2.11: Arduino IDE software interface

2.5.2.2 Proteus Isis Design Suite

The Proteus Design Suite is a proprietary software tool suite used primarily for electronic design automation. The software is used mainly by electronic design engineers and technicians to create schematics and electronic prints for manufacturing printed circuit boards. It was developed in Yorkshire, England by Labcenter Electronics Ltd and is available in English, French, Spanish and Chinese languages. Proteus is a Virtual System Modelling and circuit simulation application. The suite combines mixed mode SPICE circuit simulation, animated components and microprocessor models to facilitate co-simulation of complete microcontroller based designs. Proteus also has the ability to simulate the interaction between software running on a microcontroller and any analog or digital electronics connected to it. It simulates Input / Output ports, interrupts, timers, USARTs and all other peripherals present on each supported processor. The micro-controller simulation in Proteus works by applying either a hex file or a debug file to the microcontroller part on the schematic. It is then co-simulated along with any analog and digital electronics connected to it. This enables its use in a broad spectrum of project prototyping in areas such as motor control, temperature control and user interface design. It also finds use in the general hobbyist community and, since no hardware is required, is convenient to use as a training or teaching tool. Support is available for co-simulation of:

- Microchip Technologies PIC10, PIC12, PIC16,PIC18,PIC24,dsPIC33 Microcontrollers.
- Atmel AVR (and Arduino), 8051 and ARM Cortex-M3 Microcontrollers
- NXP 8051, ARM7, ARM Cortex-M0 and ARM Cortex-M3 Microcontrollers.
- Texas Instruments MSP430, PICCOLO DSP and ARM Cortex-M3 Microcontrollers.

- Parallax Basic Stamp, Freescale HC11, 8086 Microcontrollers.

2.5.2.3 Fritzing

Fritzing is an open source initiative to develop amateur or hobby CAD software for the design of electronics hardware, to support designers and artists ready to move from experimenting with a prototype to building a more permanent circuit. It was developed at the University of Applied Sciences of Potsdam. The software is created in the spirit of the Processing programming language and the Arduino microcontroller and allows a designer, artist, researcher, or hobbyist to document their Arduino-based prototype and create a PCB layout for manufacturing. The associated website helps users share and discuss drafts and experiences as well as to reduce manufacturing costs.

Fritzing can be seen as an electronic design automation (EDA) tool for non-engineers: the input metaphor is inspired by the environment of designers (the breadboard-based prototype), while the output is focused on accessible means of production. As of December 2, 2014 Fritzing has made a code view option, where one can modify code and upload it directly to an Arduino device.

Component images are distributed under CC-BY-SA, which will also be the license for any generated breadboard views.

2.6 Related Works

An internet based home automation system focuses on controlling home electronic devices irrespective of whether someone is inside or outside of the house. The words appliance and devices have been utilized in this project interchangeably. Automation is the current trend, where devices are being controlled automatically. The usual operation of a home automation system till now was focused on the basic tasks of turning

ON/OFF different devices either remotely or in close proximity. Technological enhancement has permitted researchers and developers to use bluetooth or Wi-Fi technology to connect different devices in a home automation system. In earlier days, Home Automation System was controlled remotely using telephone sets and telephone network. Initially PC along with the telephone network has been developed for the purpose of home automation system. Dual Tone Multi Frequency signals (DTMF) have been sent from a sender telephone (DTMF type) to a receiver telephone (DTMF type) through telephone line and an on-off hook detector, a ring detector and a PC has been incorporated within the system. The interfacing between the system and the PC has been done through an I/O interface card inserted in the expansion slot of the PC. The software part is written in TURBO basic and assembly language. Authentication check has been introduced within this system by password cross checking (Koyuncu, 1995). In a later stage, the PC was replaced by an electronic control circuit specially designed for home automation system. The various components of the control circuit are: a microcontroller and different logic control devices .In this upgraded system, a ring counter and a pass code detector were also incorporated in addition to the ring detector. The control circuit is capable of driving and controlling different home appliances efficiently (Cogkun et al. 1998). In later phase, some researchers developed a wireless LAN based home automation system which transmits video data and can control variety of appliances wisely using TCP/IP technology along with anti-theft alarming system with DTMF technology. With this added functionality, users can view the status of their home and family by accessing the network through its' own website. With the invention of mobile technology, researchers found an interesting idea of utilizing this mobile technology within the home automation area. It LED to the development of home automation system based on SMS (Short Message Service) technology where GSM

modem was used and the modem was the interface between the home automation system and the user. This modem exchanged information by SMS. A microcontroller has been incorporated in between the modem and various sensors and actuators to control the system precisely and quickly (Elkamchouchi et al., 2012). After that, home automation control using remote, has been developed. But these technologies have their own advantages and disadvantages. The main disadvantage of remote controlled system is that the operating range is low and it cannot be controlled from outside. DTMF and mobile phone based system has eliminated this problem with an additional increase of costing as the modern DTMF based system requires two mobile handsets (one for calling and one for receiving the call) and there will be call charges imposed from the service provider to the individual for each call.

Another disadvantage of this system is: there is no feedback available about the current status of the device (whether the device is presently ON/OFF). So, the user has to be sure about the exact status of the device before making any change in state. Bluetooth technology and later on, Wi-Fi technology have replaced the older technologies and occupied the market of home automation system as these two technologies completely eliminates the drawbacks of the previously existing systems. Bluetooth technology is cost effective in comparison with the Wi-Fi based system as it works offline. But if bluetooth technology is incorporated, the operating range of controlling various devices is wide (many ranges are available), but it is limited i.e. the system cannot be controlled from anywhere around the world. In contrast to that, internet based system is versatile and can be controlled form anywhere we want. Automation has become a part and parcel of our day to day life. With the advancement of Technology, demands of people are not at all limited to the basic tasks of turning ON/OFF certain devices , but also

spread over a wide range of precise, smooth and fast control and regulation of various devices either remotely or in close proximity.

A Blue-tooth based home automation system using cell phone has been proposed (Piyare & Tazil, Bluetooth Based Home Autmation System using Cell-phone, 2014). An Arduino Bluetooth board has been proposed to be connected with different devices by relays and I/O ports. The cell phone has to be connected wirelessly with the Blue-tooth module. Password cross checking has also been discussed to prevent unauthorized users. An Arduino based home automation system using micro web server with IP connectivity has been used to monitor and control (only ON/OFF control) of different devices (David, 2015).

An arduino based home automation system was designed and implemented using Ethernet shield and Wi-Fi technology , equipped with voice activation system to serve the elderly and disabled persons (Kumar S. , 2014).

A home automation system based on Bluetooth wireless technology and cell phone, allowing the user to monitor and control (only ON/OFF control) different appliances connected into the network, has been discussed (Bader, Iman, Mahdi, Sami, & Mohamed, 2014)

A smart home control and monitoring system utilizing smart phone, Android app and an embedded micro web server, having IP connectivity to access and control various devices appliances remotely, was also developed by Piyare et al, (2013). It used REST Representational State Transfer) full web services and Arduino Ethernet.

Another system architecture based on smart phone was proposed having three tiers, Common Object Request Broker Architecture (CORBA) operating system related distributed control system has been discussed. A low cost and wireless controlled automation system was designed by researchers. Bluetooth technology was used to provide remote controlled wireless access to user. Although this system achieved high accuracy but it only aimed to provide facilities and assistance to disabled and elderly (Ramlee, Othman, Leong, Ismail, & Ranjit, 2013).

Asadullah and Raza (2016) presented an overview of different home automation systems. Authors highlight the advantages and disadvantages of different technologies such as Bluetooth, ZigBee, GSM and EnOcean. The Bluetooth based automation system is low cost and enables the user to control appliances within the range of bluetooth network.

An iCloud based home automation system for precise monitoring and control (ON/OFF control) of various home appliances was put up by Raghavan (2015). An Embodied Conversational Agents (ECA) based home automation system was proposed (Santos, 2013). Other areas of automation like advanced traffic channeling, public place securities etc. was also achieved (Kumar, 2015). Which gives an insight into the current emerging areas of automation?

The developed project is an extensible system that is able to incorporate more than a single system into one. The systems include automatic switching of security lights, and smart home energy saver.

CHAPTER THREE

DESIGN METHODOLOGY

3.1 Design issues

This chapter describes briefly the interconnection of the various hardware and software components that make up the smart home system including their functional, electrical, mechanical and procedural requirements (for the hardware) and also the tools needed for programming and simulating the entire system. The various systems that that will be incorporated to make the home smart such as automatic gate, automatic security light, remote controlled door, and automatic doors (motion activated door) and temperature controlled fan.

3.2 Various Solutions Incorporated in this Project

This system is a hybridization of multiple systems controlled by a single microcontroller.

3.2.1 Automatic Security Light Control

An automatic security light control is a light that goes off when there is sunlight and goes on when there is darkness. It saves energy by putting off the lights during the day and doesn't require human intervention. It finds application mostly in streetlights. For the purpose of this project, an LDR will be implemented to sense the intensity of light in the surrounding to know whether it is day or night.

3.2.2 Automatic Smart Energy Saver for Home Appliances

The purpose of this is to save energy when no one is at home. This facility automatically senses whether there are humans in the house and in the absence of none, it automatically shuts off the power source. Research has shown that energy bills can be

reduced by 50% if electrical appliances are properly managed in terms of when in use and when not in use.

3.1 System Analysis

The individual systems are built separately, and later integrated to show the modularity and extensibility of the smart home system.

3.4 Design of Automatic Security Lights

Automatic security light control is used to control the security lights (Turn on and off based on the light). This was done by interfacing LDR (Light Dependent Resistor) and LED (Light Emitting diode) and arduino Uno board.

Circuit Diagram

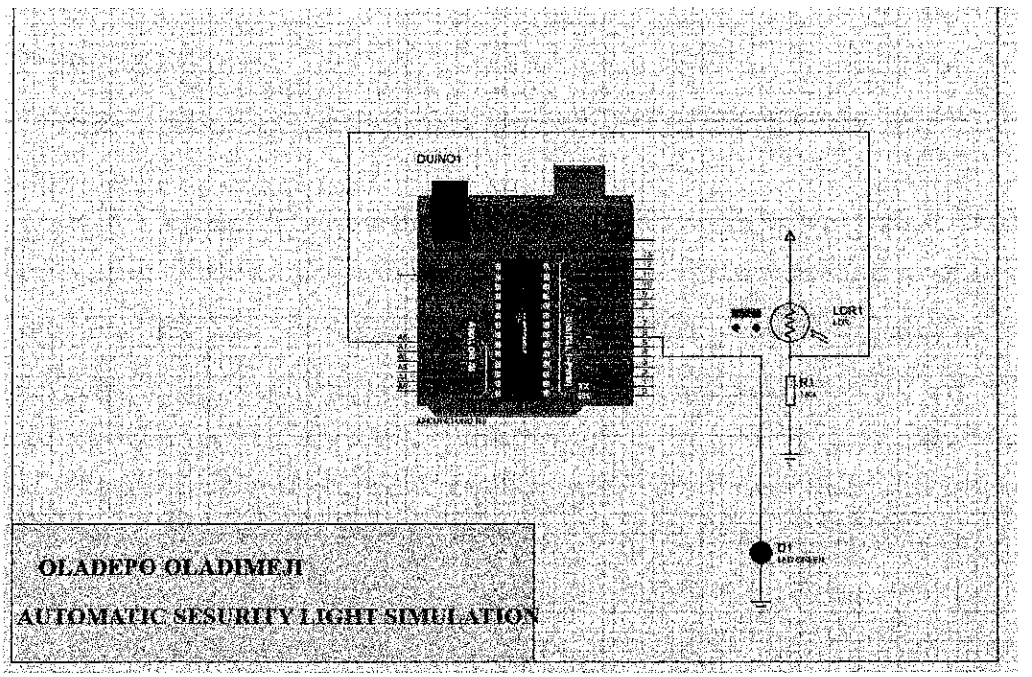

Figure 3.1: Simulation result of security light.

Hard ware Components Required Include:

i. LDR

ii. LED

iii. 10k ohms Resistor

iv. Jumper wires

v. Arduino

Hardware Connections Procedure:

i. One end of the LDR is connected to a 10k ohms resistor

ii. The other end is connected to Arduino ground

iii. One end of the resistor () is connected to Arduino 5v

iv. The Point where the LDR and the resistor are connected together is connected to the arduino A0.

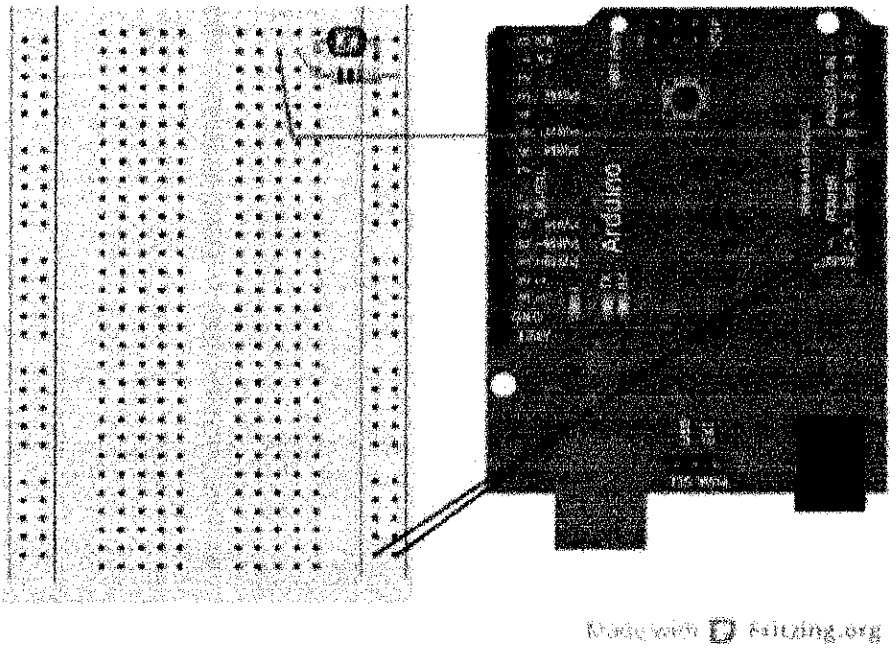

Figure 3.2: Hardware connection of automatic security

Programming, Compiling and Uploading to Arduino:

The code was written with the arduino IDE, and it is compiled and uploaded to the arduino. The code is attached to the appendix 1 of this report.

Implementation of the Automatic Security Light in the Smart Home Project:

When there is low amount of light, the bulb automatically glows and when there is sufficient amount of light it automatically turns off the light.

3.5 Design of an Automatic Smart Energy Saving Home Appliances

This system controls the automatic powering of the home appliances such as fans, room lights, televisions etc. when it senses the presence of an individual in the house. It does this with the aid of a passive infrared radiation sensor that detects the presence of human by sensing the infrared radiation emitted by the human body. If no one is at

home, it automatically shut off power to the electric and/or wall sockets. For the purpose of this project, LEDs are used to represents various appliances in the house. Some appliances in the house may require that they should be always on, therefore the system is built such that some appliances are isolated from the design so that they are not cut off from power when someone isn't home.

Hard ware Components Required Include:

i. LED

ii. Jumper wires

iii. PIR sensor

iv. 270 ohms resistor

Hardware Connections Procedure:

i. The positive end of the LEDs is connected to arduino digital pin 7

ii. The other end of the LEDs is connected to GND

iii. The DO pin of the PIR is connected to arduino digital pin 8

iv. The VCC and Ground is connected to Arduino 5v and GND respectively.

Programming, Compiling and Uploading to Arduino:

The code was written with the arduino IDE, and it is compiled and uploaded to the arduino. The code is attached to the appendix 1b of this report.

Implementation of the Automatic Security Light in the Smart Home Project:

This system checks for presence of someone, and once it is detected, it switches on the electric/wall socket of the house. The designed is done such that some apliances will always be connected to power at all times. Appliances such as freezers, home heaters e.t.c require that they are connected to power at all times.

3.6 Interfacing of all the two Systems Together

A single arduino Uno board was used to interface the various sub-systems that make up the smart home. The codes are rewritten so that the various input pins are separated to avoid conflicting connections. The system is built to be an extensible system so that it can be improved upon easily.

3.6.1 Circuit Diagram

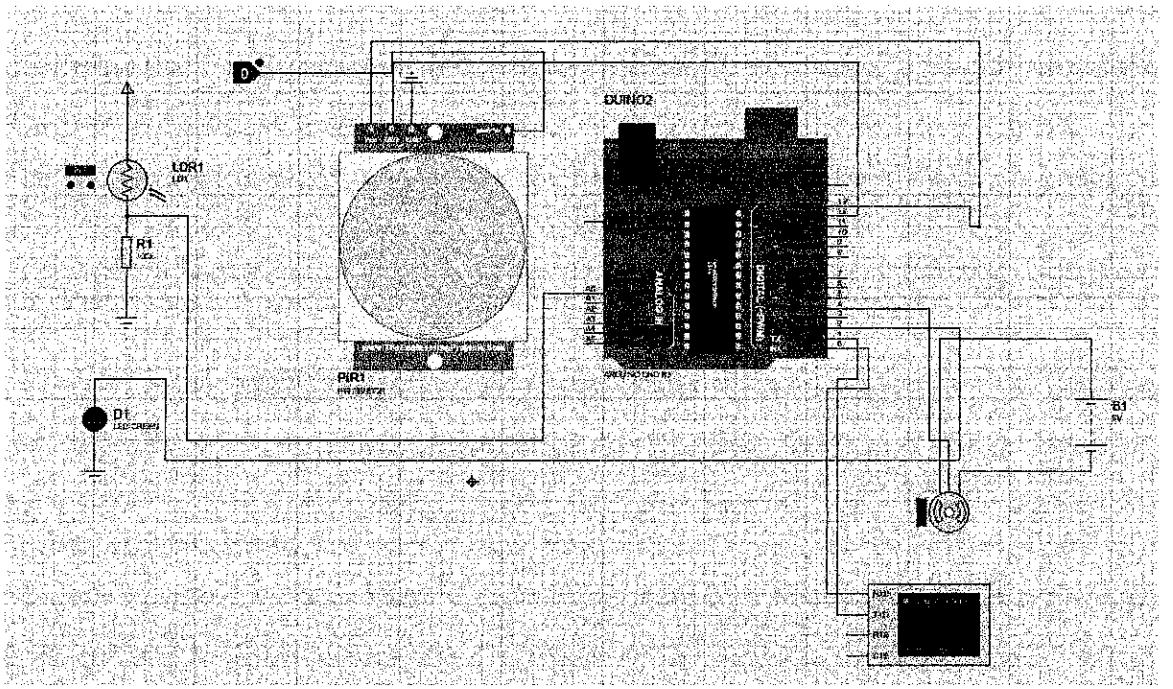

Figure 3.2: Hardware connection of the two system using proteaus

System Operation Flow Algorithm

i. Start

ii. Pir sensor senses motion

iii. The microcontroller triggers the actuator (servo, LED fan etc.)

iv. The m.c sends triggers the servo motor which opens the door to various rooms in a house.

v. As soon as motion is detected in the house, power is supplied to the electric sockets.

vi. If presence is no longer detected, power is cut out of the sockets to save energy

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 Analysis of the System

This chapter discusses the hardware implementation and simulation result of the developed system. The simulation was done using proteus design suite before carrying out the hardware implementation of the real prototype. A dummy house was made from plywood with an opening to allow ease of access during hardware installation.

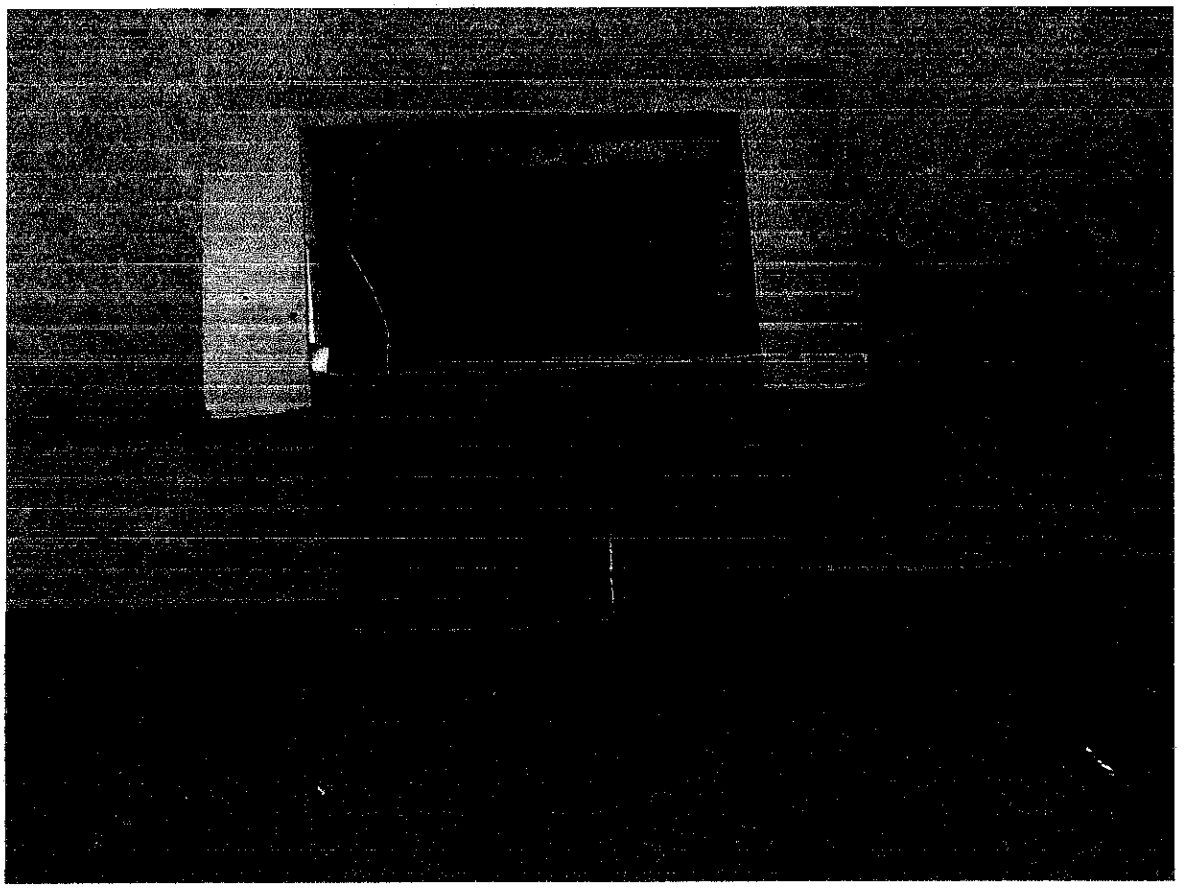

Plate 4.1: House prototype made from plywood

4.2 Result of the Automatic Security Light Simulation

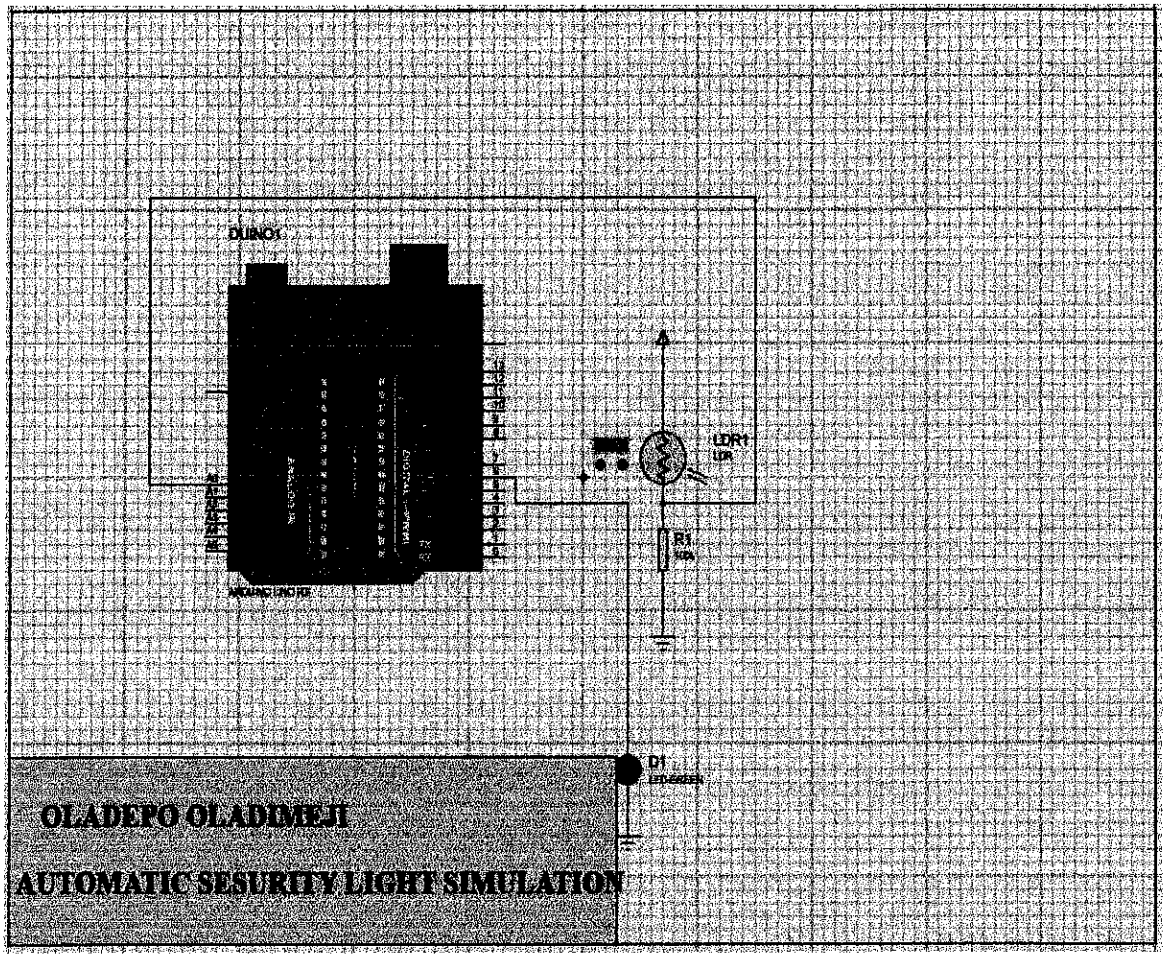

Figure 4.1: Simulation result of the automatic security light

4.2.1 Testing of the security light

It was tested in various light conditions such as when the light is very bright, bright, light, dim and dark with each condition having analog readings of greater than 800, less than 800, less than 600, less than 400 and less than 200 respectively. The chosen value was greater than or equal to 600 because this covers for evening period from around the hours of 7:00 p.m. to 6:30 am in the morning (based on my own findings).

4.2 Result of the Automatic Security Light Simulation

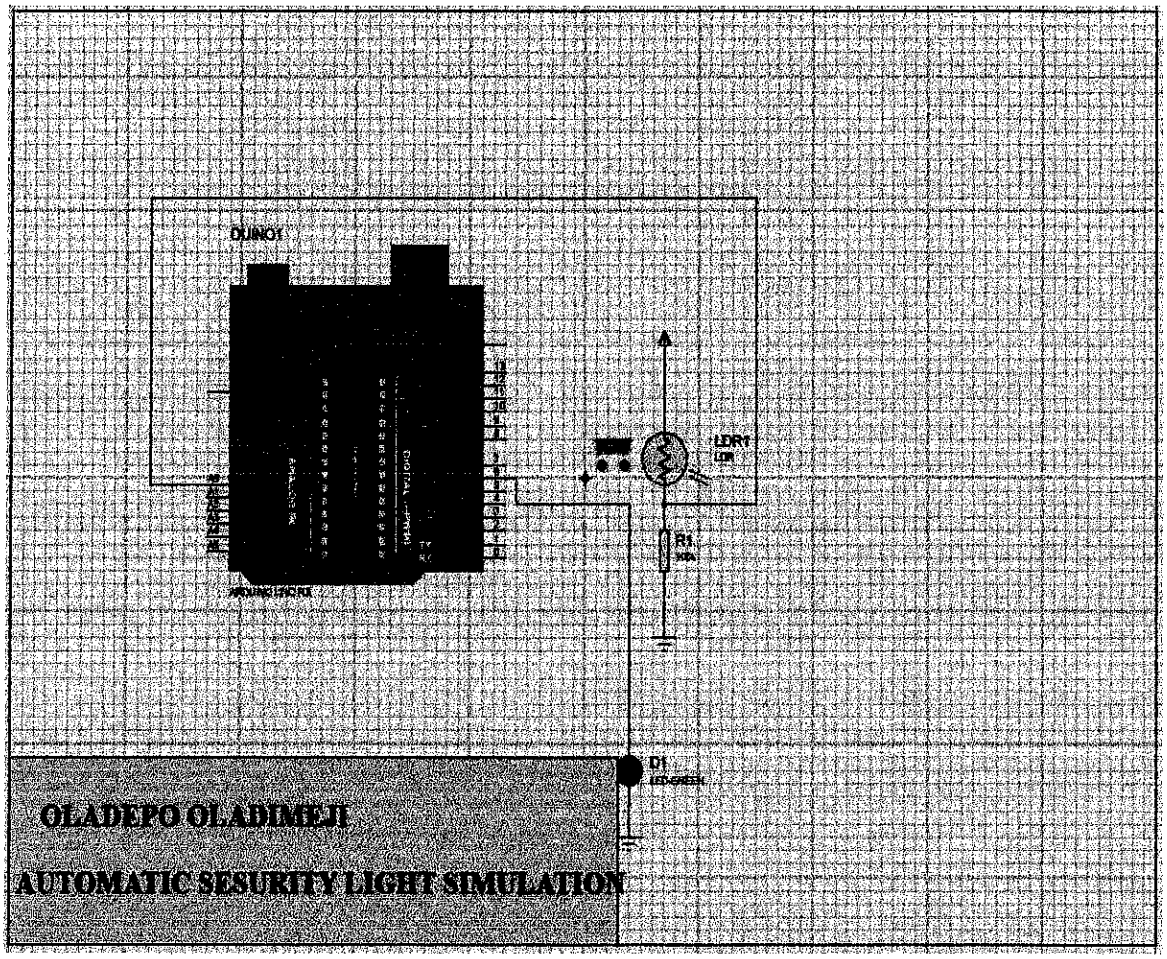

Figure 4.1: Simulation result of the automatic security light

4.2.1 Testing of the security light

It was tested in various light conditions such as when the light is very bright, bright, light, dim and dark with each condition having analog readings of greater than 800, less than 800, less than 600, less than 400 and less than 200 respectively. The chosen value was greater than or equal to 600 because this covers for evening period from around the hours of 7:00 p.m. to 6:30 am in the morning (based on my own findings).

4.3.1 Testing and discussion

The PIR sensor is first allowed to calibrate itself to suite the environment where it will be used, after that, any change in the environment caused by an emission of infrared radiation other than the ones it is already familiar with during calibration is then detected. Its operating range is less than 1 meters, therefore, the person have to be close to the door before the door will be opened.

4.3.2 Drawbacks

If any object that emits infrared radiation comes close to the door, the microcontroller assume it is human and triggers the door open. Another instance is when someone or any infrared radiating object passes through the door but not necessarily going through the door, the door may also open which may be actually be uncalled for.

Any car or human that comes close to this gate is allowed to enter without authentication or authorization. This will most likely lead to a security/safety flaw.

4.4 Result of Automatic Control of Home Appliances for Energy Saving

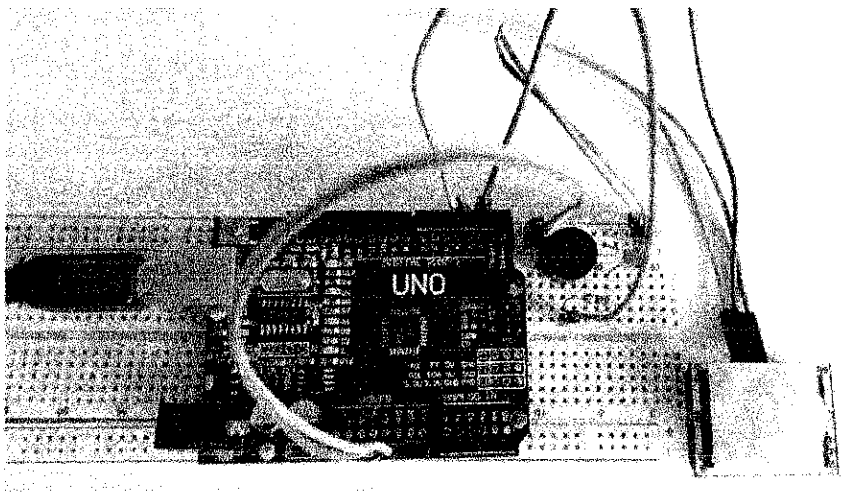

Plate 1: Breadboard prototype result of automatic control of appliances

4.4.1 Testing and Discussion

The arduino is programmed such that if the PIR sensor does not detect changes in infrared radiation emitted by humans for a preset time, power will be cut out of the house. This system does not affect the security light but only the interior of the home.

4.4.2 Drawbacks and Recommendation

If any object that emits infrared radiation is in the house, the entire house will be on except if the home owner switches off the appliances manually. A better human presence sensor should be implemented such as a remote home monitoring technique that utilizes wireless control to switch / control appliances from a remote location albeit, this might increase the overall cost of the system.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This chapter concludes the project by highlighting its merits and demerits and how it can be improved upon in later works.

The system has proven to be an efficient and yet a cost effective solution for basic needs in our homes in terms of handling repetitive task such as in the switching of security lights and efficient power management and security of homes.

5.1.1 Merits

i. It is very cheap compared to the existing smart home automation systems. It cost less than $30 which is equivalent to 7,500 naira as at the time on writing.
ii. It can be easily implemented in new and existing homes.
iii. It reduces electrical energy consumption, thereby reducing energy bills

5.1.2 Demerits

i. Sensors are not very accurate. It is subjected to false sensing that may trigger unwanted operations in the smart home.
ii. Safety measures are not in place

5.2 Recommendations

Developers should try to add more functionalities to the system such as water level indicator, energy consumption indicator, fire/smoke alarms etc. More accurate sensing devices can be implemented in the design for a more precise sensing of humans.

Examples include facial recognition systems or speech based home automation system, biometrics etc.

More safety and security features should be implemented in later works so as to improve the safety and security of lives and properties in the homes.

Smart home system developers should try to make the system very cost effective so that it can be affordable for most home owners especially in developing countries like Nigeria.

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APPENDIX IA

Automatic Energy Saver Code

```
int calibrationTime = 10;
//the time when the sensor outputs a low impulse
long unsigned int lowIn;
//the amount of milliseconds the sensor has to be low
//before we assume all motion has stopped
long unsigned int pause = 1000;

boolean lockLow = true;
boolean takeLowTime;

int pirPin = 7;    //the digital pin connected to the PIR sensor's output
int LEDPin = 8;


/////////////////////////////
//SETUP
void setup(){
 Serial.begin(9600);
 pinMode(pirPin, INPUT);
 pinMode(LEDPin, OUTPUT);
 digitalWrite(pirPin, LOW);
```

```
  //give the sensor some time to calibrate
  Serial.print("calibrating sensor ");
    for(int i = 0; i < calibrationTime; i++){
      Serial.print(".");
      delay(1000);
      }
    Serial.println(" done");
    Serial.println("SENSOR ACTIVE");
    delay(50);
  }
////////////////////////////
//LOOP
void loop(){

    if(digitalRead(pirPin) == HIGH){
      digitalWrite(LEDPin, HIGH);   //the LED visualizes the sensors output pin state
      if(lockLow){
        //makes sure we wait for a transition to LOW before any further output is made:
        lockLow = false;
        Serial.println("---");
```

```
      Serial.print("motion detected at ");
      Serial.print(millis()/1000);
      Serial.println(" sec");
      delay(50);
      }
      takeLowTime = true;
    }

  if(digitalRead(pirPin) == LOW){
    digitalWrite(LEDPin, LOW);  //the LED visualizes the sensors output pin state
    if(takeLowTime){
    lowIn = millis();          //save the time of the transition from high to LOW
    takeLowTime = false;       //make sure this is only done at the start of a LOW phase
    }
    //if the sensor is low for more than the given pause,
    //we assume that no more motion is going to happen
    if(!lockLow && millis() - lowIn > pause){
      //makes sure this block of code is only executed again after
      //a new motion sequence has been detected
      lockLow = true;
      Serial.print("motion ended at ");     //output
```

```
        Serial.print((millis() - pause)/1000);
        Serial.println(" sec");
        delay(50);
        }
    }
 }
```

Automatic Security Light

```
int kPin_Photocell = A0;

int LED=6;
void setup(){
Serial.begin(9600);
}

void loop()
{
int value = analogRead(kPin_Photocell);
if(value <=600){
digitalWrite(LED,HIGH);
}
else if(value >= 700){
digitalWrite(LED,LOW);
```

```
}
Serial.print("Analog Reading = ");
Serial.print(value);
if(value < 200){
Serial.println(" - Dark");
}
else if(value < 400){
Serial.println(" - Dim");
}
else if(value < 600){
Serial.println(" - Light");
}
else if(value < 800){
Serial.println(" - Bright");
}
else{
Serial.println(" - Very Bright");
}
delay(1000);
}
```

APPENDIX 1B

The entire Smart Home system code

```
#include<Servo.h>
int LDR=A0;
int PIR_inside=3;
int led_outside=7;
int led_inside=13;
int PIR_door=8;
int servo=10;
int led_general=12;
Servo door;
void setup() {
  // put your setup code here, to run once:
pinMode(LDR,INPUT);
pinMode(PIR_inside,INPUT);
pinMode(PIR_door,INPUT);
pinMode(led_outside,OUTPUT);
pinMode(led_inside,OUTPUT);
pinMode(led_general,OUTPUT);
door.attach(servo);
door.write(0);
digitalWrite(led_general,LOW);
}
```

```
void loop() {
  // put your main code here, to run repeatedly:
digitalWrite(led_general,HIGH);
int value = analogRead(LDR);
if(value <=600){
digitalWrite(led_outside,HIGH);
}
if(value >= 700){
digitalWrite(led_outside,LOW);
}
if(digitalRead(PIR_inside)==HIGH){
 digitalWrite(led_inside,HIGH);
 delay(2000);
}
if(digitalRead(PIR_inside)==LOW){
 delay(4000);
 if(digitalRead(PIR_inside)==HIGH){
  digitalWrite(led_inside,HIGH);
 }
 else{
  delay(2000);
  digitalWrite(led_inside,LOW);
```

```
 }
 }
 if(digitalRead(PIR_door)==HIGH){
door.write(90);
delay(3000);
door.write(0);
}
}
```

APPENDIX II

Bill of Engineering Measurement and Evaluation

Qty.	Description	Cost (Naira)	Total (Naira)
4	RESISTOR 270 OHM	50	200
1	ARDUINO	1,500	1,500
1	PIR SENSOR	200	200
10	LED	10	100
1	9 V BATTERY	150	150
4	RESISTOR, 10K OHM	50	200
1	VERO BOARD	100	100
1	ARDUINO CASING	500	500
1	SOLDERING LEAD	100	100
50	CONNECTOR/JUMPER WIRE	10	500
2	SERVO MOTOR	800	1600
1	PLY WOOD	2500	2500
	TOTAL (Naira)		7650