DEVELOPMENT OF A DIGITAL ROBOT FOR MOPPING, MOWING AND SURVEILLANCE

BY

EHIRIM ERNEST ARINZE (B.ENG)

20184142338

A THESIS SUBMITTED TO THE

SCHOOL OF POSTGRADUATE STUDIES

FEDERAL UNIVERSITY OF TECHNOLOGY OWERRI

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF ENGINEERING DEGREE (M.ENG) IN COMMUNICATION ENGINEERING,

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ENGR. DR. N. CHUKWUCHEKWA

February, 2022

CERTIFICATION

I certify that this work "Development of A Digital Robot for Mopping, Mowing and Surveillance" was carried out by Ehirim Ernest Arinze (20184142338) in partial fulfillment of the requirements for the award of the degree, Master of Engineering (M.Eng) in Communication Engineering in the Department of Electrical Electronics Engineering, Federal University of Technology, Owerri.

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DEDICATION

This work is dedicated to God Almighty.

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LIST OF ABBREVIATIONS

4G	Fourth Generation
AC	Alternating Current
AI	Artificial Intelligence
AMPS	Ampere
CCTV	Closed Circuit Television
DC	Direct Current
GPIO	General Purpose Input Output
DTMF	Dual Tone Multiple Frequency
FCC	Federal Communication Commission
FPGA	Field Programmable Gate Array
IP	Internet Protocol
IEEE	Institute of Electrical and Electronics Engineers
IOT	Internet of Things
IC	Integrated Circuit
LDS	Laser Distance Sensor
LTE	Long Term Evolution
MHz	Mega Hertz
NC	Normally Closed
NO	Normally Open
PBT	Pixel Brightness Transformations
PCB	Printed Circuit Board
PHCN	Power Holding Company of Nigeria
PLC	Programmable Logic Controller

RFID	Radio Frequency Identification
UAV	Unmanned Ariel Vehicle
VNC	Virtual Network Computing
WIFI	Wireless Fidelity

ABSTRACT

This digital robot was designed for mopping, mowing and surveillance, it was built with common technology using the raspberry pi microcomputer, a PIC 16F877A micro-controller, ultrasonic sensors, camera, and some more components. This machine was designed to carry out tasks autonomously with little human assistance and in remote control mode. In autonomous mode the machine uses its sensors to detect objects on its path and avoid them without any physical contact.

The robot could carryout survey in an environment using its surveillance features which include camera and relay of video footage over the internet to a control base. This robot was designed to carry out tasks which are life threatening or tedious for humans to do. The machine could mow grasses to about two centimetres in height, mop floors and survey an environment. For the robot to function, the drive mechanisms involving the wheels and it's actuators were developed using electric direct current motors and rubber tires, a radio communication channel was also developed. Remote control used in the robot is the HT12 series encoder and decoder, and also Virtual Networking using WIFI to provide internet access for control over the internet, sensors for autonomous navigation were integrated. Power system and some other electronic systems for the robot were also integrated. The power system provided power for approximately one hour thirty minutes without sunlight and between two to three hours of functionality under sunlight thereby optimising power usage. The surveillance system and the wireless internet connectivity enabled remote control over a long distance. The mopping section was developed with a Plastic container and pipped with polyvinyl materials and a drying mop. Using its sensors, the machine was able to navigate its way through a well defined environment without problems and operating effectively with little human assistance. Proper functionality of the system was eventually validated. The machine was completely built and can be further developed by improving its program and adding more sensors.

Keywords: Lawnmower, Surveillance, Renewable energy, Robots, Actuators

CHAPTER ONE

INTRODUCTION

1.1 Background of Study

Robotic engineers have designed and built robotic systems used in homes, offices, airports with optimum performance and balance of functionality, ease-of-use, and cost effectiveness. Robots can clean floors, mow lawns, guard homes and also help the old and handicapped. They can do some surgeries, inspect pipes and environments that are hazardous to people, they fight fires and defuse bombs. In this thesis, a robot was designed and implemented for the sole purpose of mopping floors, mowing the lawns, and surveillance of an environment (security). The already in use floor cleaning machines are mostly used in airports, offices, railways, etc. and have been found to lack some basic life saving features. These features are covered exclusively within this report and implemented within the design of the robot.

Effective cleaning and sanitizing help protect the health of the humans directly and indirectly, and also keeping the environment clean and tidy. Cleaning and sanitizing reduces residues that can attract and support animals, bacteria, viruses etc. (Ranjit et al, 2015). In recent years, most people prefer natural grasses within the compound to help keep the environment green. This comes with its own challenges, which include maintaining the lawn and keeping it tidy. Work has been done, and machines have been built, but machines built and in use today pose challenges which are not yet solved, even though they do the work they are designed to do, they still bring problems to users and the environment at large. The mowing machines in existence have contributed to the depletion of the Ozone layer leading to rise in temperature of the planet which has lead to melting of polar ice causing flooding world wide, wildfires and lots more. These mowing machine have caused more harm to humanity at large, and to individuals using them, sometimes users of these machines are diagnosed of ear loss, high blood pressure, body pains, headaches and lots more.

The mopping machines used today are effective because most of them are used indoors and are usually small in size. They are rechargeable with power supply from power outlets in home, these make it impossible for use in homes and environments without steady power supply. These machines are smart, robust, but are mostly limited in functionality. Mopping machines in existence do not usually function for a long time due to it's battery limitations, they also do not have the ability to store large volume of water for mopping large surface area.

Surveillance systems commercially available today are the common closed circuit television (CCTV), these are fixed surveillance systems which are not mobile, mobile surveillance systems in existence are mainly used by the military and are not available for civilian use. Systems are been developed and surveillance is been built into drone technologies which are expensive to purchase and limited to line of sight in terms of it's wireless control.

These systems are independent systems which operate as a separate entity which means that when one is in use at the home or office the other will also need to be purchased separately for it's dedicated separate task. This makes mowing, mopping and surveillance expensive because each of these separate systems must be separately maintained when purchased. The emissions from the machines are not friendly to environment.

The mopping, mowing and surveillance robot (surveillance robot) is a three in one machine which is aimed to be efficient and effective in the work it will do. The machine is built to cut down cost of purchasing three independent machines for the three tasks, solve the basic problem of cost and maintenance, reduce stress on users, and also aid to improve the environment by it's no emission.

To actualise this machine, solar power is used to provide energy source making it a self sufficient machine, user friendly and fun to use. It is autonomous, and it's autonomy is controlled by the use of

Raspberry Pi, micro-controller and some embedded devices within it. The microchip sends and receives binary signals to sensors on the robot to aid it's navigation. In remote mode, a radio frequency control system is used to enable the user control the machine in his or her leisure time or in case of an undefined environment.

With the surveillance capabilities, it is aimed that an operator can remotely control the machine from anywhere globally, and can also survey and watch over an environment through an onboard micro computer and micro camera system. This surveillance feature is also aimed to be used to known when an environment needs mowing, and it could also be life saving when deployed to survey an environment which is not safe or an area with poor security and unforeseen elements like an improvised explosive device. Finally the study aims at solving problem of cost of purchasing mowing and mopping machine, it also provides safety when used for surveillance of a hazardous environment, complexity in designing autonomous mowing and mopping machine is reduced, power issues in machines and also contribute to reduction in emission through its renewable energy source.

1.2 Statement of the problem

Floor cleaning has been a tedious work for people over the years. The stress of spending hours upon hours to get our floors clean is a challenge. Machines do work faster and more precisely than humans do. Machines have been built to clean floors and mow over the years but a problem still linger in the design of these machines, this is the problem of power, ease of use and multitasking. In countries like Nigeria where power is a challenge, these machines find it difficult to operate. Endless resources are spent on petrol and diesel to power most of the lawn mowers commercially available.

The machines in existence are usually pushed around or carried on the back. This wastes precious time that could have been used for something more important and more productive. These machines cannot be used by the old and the young, they are not multitasking, and cannot survey an environment for security purposes. High cost of purchasing separate mopping machines, mowing machine and surveillance systems and their maintenance are unbearable.

Problems of power is solved through the use of solar power cells and battery technology, cost is reduced because of the integration of two machines into one through its mowing and mopping features, easy maintenance because of the lack of complexity, cheap and easy design of system components. Security challenges posed by an environment could be solved using the surveillance features and eliminating treat to life.

1.3 Aim and objectives of study

The aim of this work is to develop a digital robot for mopping, mowing and surveillance.

The specific objectives are to:

i. develop drive mechanism for mopping, mowing, and surveillance using Autocad Autodesk 2022

ii. develop a Radio communication channel for robot navigation using Wi-Fi over the internet, Radio Frequency and Ultrasonic.

iii. develop power and electronic systems for the robot mopping, mowing and surveillance.

iv. develop python and PIC program for computer vision and autonomous robot navigation for mopping, mowing and surveillance

v. test the operation of the developed system.

1.4 Justification of study

Considering the need to reduce stress, time wasted in mopping and mowing, and the environmental challenge the current style of mowing and mopping has brought, it has become a necessity to phase out the combustion engines that have become problematic to both human and the environment at large. This proposed Eco-friendly programmable robotic system can mop a spot at above 100 times a second and lawn mowing with roughly the same speed with little or no human interference, this speed of operation is directly proportional to battery voltage. This machine can also solve the problem of theft in an environment because it has capabilities within it to see and monitor the environment in the absence of the owner. It is a digital software-controlled machine that gives real time monitoring of the environment with control abilities over the internet. This makes it much effective than human and most machines of its kind. This system is stress free to use because it could work autonomously with its navigation sensors instead of been pushed around, it is noise free because it uses electric motors and not internal combustion engines which are usually noisy, it can as well entertain the user since it can be controlled with a remote or over the internet. This system requires little or no services due to its less functional parts (no gears and belt systems), services required maybe changing of batteries when damaged and sharpening of the blade when blunt. It is the perfect machine for the job of mowing, mopping and surveillance in 21^{st} century.

1.5 Scope of study

The scope of the study is primarily on the design of a three in one machine which could function as a mopping, mowing and a surveillance robot. Within the design, the machine would have a drive mechanism designed for it using electric actuators, an autonomous navigation system using an onboard microcontoller and series of sensors. An electronic system which would be powered by solar and battery, a remote control subsystem for navigation using virtual network computing VNC, and line of sight remote control using radio frequency transmittter and receiver. Computer vision using open computer vision is to be embedded on the machine to enable effective surveillance.

The machine is to be designed to function and carry out its tasks, with an autonomous navigation which would be above 90% efficient, mopping with an efficiency of above 90%, surveillance features with efficiency of 90% and power generation of 98%. The system is also to be completely built with little or no modifications needed.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction to Artificial Intelligence and Vehicle networks

According to Habeeb (2018), artificial intelligence (AI) is a new field in the area of computer science which focuses on the design, and building of intelligent machines that act and react like humans. Some activities which computers built with artificial intelligence carry out include but not limited to Speech recognition, Learning, Planning, Problem solving. Two branches of artificial intelligence which are most popular today are Deep learning and Machine learning. Deep Learning has activated and influenced many practical applications of Machine Learning and the entire field of AI. Deep Learning aids to break down task in ways that make all kinds of machine assist seem possible. Some examples of deep learning are deployed in automated cars, preventive and supportive healthcare, even in the movie industries and movie recommendations. Machine Learning is the practice of using algorithms to compute data, learn from it, and then make a determination or prediction about something in the future. Rather than hand-coding software with specific set of instructions to achieve and accomplish a particular task, the computer system is “trained” using many number usually large amounts of data and algorithms which gives it the ability to learn how and to perform the task (Habeeb, 2018).

2.1.1 Rapid Object Detection using a Boosted Cascade of Simple Features

An Unmanned Ariel Vehicle (UAV) has much higher use in the military for security usually at the international border. The objective of (Viola, et al. 2001) include developing and Open computer vision using Haar-Cascade algorithm in python code for face and object detection and identification. Currently, UAV’s are used for tracking detected illegal immigrants across a large area of the border. This project uses Voila-jones computer vision algorithm to detect and track anything including humans.

The algorithm involved uses cascade object detector for vision. This project involved the design and implementation of an unmanned aircraft which can be remotely controlled or re-programmed to fly with specific coordinates. It possess Image processing capabilities. Image processing is a method used to convert or alter an image which is in digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. The image processing based UAV covered within this work is not completely operational. It could detect, process and identify humans at certain accuracy from a distance (Viola, et al. 2001).

2.1.2 Virtual Network Computing

In the computing world, Virtual Network Computing (VNC) is usually not a terminal based operation but a graphical desktop-sharing system that uses the Remote Frame Buffer (RFB) protocol to control another computer connected to a network remotely. It transmits the peripherals such as the keyboard and mouse events from one computer to the remote computer usually the client, relaying the graphical-screen updates back in the other direction, over a network. VNC is truly a server-client system. Its design makes very few requirements of the client, and therefore simplifies the task of creating clients to run on a wide range of hardware. Many recent software provide Internet connections, which focus on giving users (clients) access to resources located anywhere in the world from their home computing environments. VNC provides the medium through which one can access a home computing environment from anywhere in the world. Members of the Federal University of Technology Owerri can use VNC to access their personal computers from any office in the School of Engineering building and from around the world on whatever computing infrastructure happens to be available, including confidential documents (Richardson et al., 1998).

2.1.3 Embedded Systems Engineering

Oyeniyi Oyetoke, 2015 states that embedded systems is a computer system having dedicated functions within a larger mechanical or electrical system. Embedded systems are used to control many devices we use today ranging from our phones to watches, microwave oven, heaters and lots more. More of this computers are found in automotive industries(cars, aviation, locomotive, etc).

In the embedded system, there are general purpose, application specific and single purpose hardware. Programmable Logic Controllers (PLC) are general purpose embedded system used to control machines and electronics automatically. It is a computerized microprocessor based controller that executes discrete or sequential logic in any environment. A PLC has an integrated programmable microprocessor usually reprogrammable at anytime with a suitable programming language and a compiler. After writing the PLC program it is copied to the non-volatile memory of Programmable Logic Controller through a cable connection using Serial or USB ports. These microcontrollers also called microchips are usually programmed using the PLC Basic or using C Programming language or Java and other languages as the case may be. These systems interact with the real world using sensors and actuators. (Oyeniyi et al, 2015)

2.1.4 Wireless and Radio Frequency systems

Wireless Fidelity commonly known as Wi-Fi is a technology allowing computers (Phone, PC, tablets, etc) connect to the internet at high speed without having any physical wired connection. Wi-Fi uses radio frequency signals to transmit between the internet and Wi-Fi enabled devices, this enables information and data be received from the web. This technology owes its origin to the Federal Communication Commission (FCC) America. (Bakare et al, 2019)

This technology was accepted into the wireless communications domain of the IEEE family of 802.11 standards. Wi-Fi was designed as an inexpensive alternative for the cable Ethernet connection, it does not cost much to set up and has high-bandwidth connections to the internet. The rapid acceptance led to the proliferation of inexpensive radio communication cards and new laptops having built in radio cards (Shim et al., 2006).

Wenting et al., 2007 states RFID (Radio Frequency Identification) as an automatic identification method using radio frequency. This technology allows storing and reading data from an RFID device without having to either come in contact with the reader or the tag, but have to be in a line of sight between the tag and reader. RFID has three main components which enables its workability, the transponder (tag), interrogator (reader) and antenna. In real communication systems, RFID system carries out a number of functionalities between the tag and the reader. Radio Frequency Identification readers continuously emit carrier sine waves which are picked up by a reader when in close contact. When a tag approaches the radio frequency field of a reader, the tag receives energy from the field. After receiving energy in the electromagnetic field, it modulates the carrier signal to the data storage embedded within the tag. This modulating signal is then resonated from the tag to the reader. When the reader detects this modulating signal emanating from the tag, it (the reader) decodes the signal and retrieves the data from the tag. When this is done, the information is transferred to the administrating computer where enhanced manipulation of data will be done and information stored and displayed to the administrator or user as the case may be. Radio frequency identification system relies on wireless communication using radio waves with a limited frequency of operation and is within an electromagnetic spectrum (Wenting et al., 2007).

Closed Circuit TV commonly known as CCTV systems is the origin of surveillance, (Karimaa, 2014). Usually, this system involved the use of cameras and cables and dependent on the location of both the administrator and the client of the system. Mobile client applications are recently used to provide camera video streams and other resources needed within a system required for surveillance. Camera devices connect through wireless links to overcome environmental conditions and limitations of distance. This devices can be installed at homes, buses, trains, etc. which may require wireless access to the administrator. This system displays video streams from selected camera devices connected over the network to the system and can control those cameras and also access recorded contents. This system having enhanced client capabilities can provide local content manipulation such as modification of contents, exporting and allow the user or administrator to react in certain events. System requirement is usually a set of electronic devices such as a personal computer, a mobile phone, network provider, and a camera systems (Karimaa et al, 2014).

Wireless patient monitoring system is an essential system in the world of health today, this has been made possible through Internet of Thing (IoT). This provides an easy way to monitor patients and their health without direct contact or physical presence using wireless systems and the internet. This has helped reduce the frequent visit of patients to hospitals for regular check-up and updates of their health. This system uses high speed internet to send data to concerned physicians over the mobile to a server. This makes it possible for the physician to consult and carry out medical examinations remotely. Health signs such as body temperature, blood pressure, weight, sugar level and some other vital signs are recorded and uploaded to the server wirelessly. The transmitted information is received by a software application on the doctor’s mobile through the web server, then the feedback is sent to the required station. Using the IoT enables effective and immediate care of the patients at any situation and point in time. The IoT is widely used to interconnect medical resources and devices to offer smart, effective and reliable healthcare service especially to the elderly people (Karthikamani et al., 2019).

2.1.5 Object Detection

Dominick et al, presents an intelligent machine vision system able to learn autonomously individual objects in real environment. This system relies on salient object detection. In its design, they were inspired by early processing stages of human visual system through the primary visual cortex of the human brain, they suggest a novel fast algorithm for visually salient object detection, robust to real-world illumination conditions. Then they use it to extract salient objects which can be efficiently used for training a machine learning-based object detection and recognition unit of any proposed system. They provide results of their salient object detection algorithm on Microsoft Research Alumi Salient Object Database benchmark, comparing its quality with other state-of-the-art approaches. This system has been implemented on a humanoid robot, increasing its autonomy in learning and interaction with humans.

Dominick et al system happens to be an effective way to train a system to identify objects in a vicinity in real time. I could not use this Dominick system because of the high computing power needed to run his software packages.

2.1.6 Raspberry Pi as Internet of Things hardware: Performances and Constraints

Internet of Things -IoT, is a very dynamic networked system, it is has numerous large number of smart gadgets connected together which talk to each other and interact the digital way. These smart devices use sensors to sense the real world environment and translate them into digital signals which are used as a source of information for the control and actualization of effects in the environment. These smart objects play important role in IoT. These technology can access the internet, store information interact with themselves and with humans too. The Raspberry pi is a small computer, it is cheap to purchase, it has flexible capabilities which makes it possible to be used like a microcontroller using a Linux operating system, it is an education-oriented system designed in Oxford primarily for teaching children how to program, it was developed and deployed in 2012. This is a standard computer which has more features for control of electronic devices, actuators and lots more (Maksimović et al., 2014).

According to Gareth Halfacree in the Official Raspberry PI beginner's guide – The Raspberry pi is an ultra-small, affordable computer, it costs less than most video games, but can be used to learn coding, build robots, and create all kinds of weird and wonderful projects. The Raspberry Pi is capable of doing all the things one would expect from a computer, everything from browsing the internet and playing games, to watching movies and listening to music. But the Raspberry Pi is much more than a modern computer.

With a Raspberry Pi you can get into the heart of a computer. You get to set up your own operating system, and can connect wires and circuits directly to the pins on its board. It was designed to teach young people how to program in languages like Scratch and Python, and all the major programming languages are included with the official operating system. People of all ages use the Raspberry Pi to create exciting projects: everything from retro games consoles to internet- connected weather stations. The pi has all the functionality we need to make this robot smart (Halfacree et al, 2018).

2.1.7 Actuators For Smart Applications

A Sensor is a device which when exposed to a physical phenomenon (temperature, displacement, force, etc.) produces a proportional output signal (electrical, mechanical, magnetic, etc.). The term transducer is commonly usually used alongside with sensors. Sensors usually have computer interpreters connected to them and actuators to effect changes when need be. However, ideally, a sensor is a device that responds to a change in the physical phenomenon. On the other hand, a transducer is a device that converts one form of energy into another form of energy. Sensors are transducers when they sense one form of energy input and output in a different form of energy. For example, a thermocouple responds to a temperature change (thermal energy) and outputs a proportional change in electromotive force (electrical energy). Therefore, a thermocouple can be called a sensor and or transducer.

An actuator is a device which could be mechanical or electrical and is usually part of a machine. Actuators which puts into action and help to achieve a physical movement intended by the machine it is attached to. Actuators are usually driven by either by electrical, hydraulic or air. It converts energy from one form to another. Sensors pick signals and usually after computations have been done by on board computers or programs, signals are usually sent to actuators which effect the physical change needed (Paternoster et al., 2010).

2.2 Review of Related Works

2.2.1 Lawn Mower

Nagarajan et al., 2017 lawn mower used helix shaped blade for grass cutting machines used in agricultural field. This is an innovative concept aimed for use primarily in agricultural fields. The components that were used in this design are wheel, gear arrangement, roller, bearing, and base frame. The gear arrangement of the tractor driving the system also drives the cutting blade, and beneath this gear, the helix cutting blade is attached, as the gear arrangement rotates, the reel mover tends to cut the plants or crops, the faster the reel, the faster the helix blade. The reel consists of several helix shaped blades mounted to a rotating shaft. The entire system is placed on a movable base which has a wheel arrangement. It can be used to maintain and upkeep lawns in football fields, gardens, schools, college's etc. In this design, sets of gears are used to mechanically drive the machine and its rotors. As the machine is being pushed around by the movable base which would be a tractor, the gears drive the wheels and the revolving blades beneath the machine. This movement of the blades perform the operation of cutting down to a reasonable height the crops intended to harvest (Nagarajan et al., 2017) .

Lever operated lawn mower is a design which cannot be used by a physically challenged or by an aged person. It requires high physical man power to use. It is usually heavy and also uses complicated set of gears which might not be easily sourced or fabricated in case of wearing out. This machine is analogous and it's design is complicated and difficult to implement due to the fact that all its belt and gear system must be properly aligned and must function as expected. In an environment where tractors are not available to drive the system about, it cannot function. It is not Eco-friendly because, the tractors use fuel which emit high amount of carbon (iv) oxide, therefore endangering our planet.

A remote controlled lawn mower was adopted by Suresh et al., 2018 to ease the stress of pushing around or carrying a backpack of this heavy machine. This project considers the implementation of a robot which can be operated using Bluetooth technology. Every action of the lawn mower is controlled by the micro controller which eliminates the use of perimeter wires to maintain the robot within the lawn. The working principle of solar grass cutter is that it has a solar panel mounted in an angle on top of the machine in such a way that it can receive solar radiation with enough intensity easily from the sun. Solar panels are designed to convert solar energy into electrical energy. This electrical energy is stored in a battery by using a solar charger. The motor is connected to the battery in the system through connecting cables. This solar powered lawnmower has a direct current (D.C.) motor, a rechargeable battery, solar panel, a steel blade among others. Mowing is achieved by the D.C. motor which provides the required torque needed to drive the stainless steel blade. This machine is designed for outdoor use only and cannot be used for mopping floors at any given time.

This machine uses the Arduino uno module with an ATMEGA 328 chip. It uses the arduino module to control the movement of the machine and the motors attached through a resistor system. In this design, a program is written and embedded into the ATMEGA 328 which is placed on the Arduino module, and motor drivers are connected to the module which supply the current signal with respect to the program controlling the device and the signal received from the Bluetooth receiver on the machine (Suresh et al., 2018).

Satwik et al., 2015 used the Arduino module and ATMEGA 328 chip deployed in there design of automatic floor cleaning machine. The ATMEGA cannot execute more instructions because of its low memory and does not support serial connection to multiple chips to increase performance. This design also uses Bluetooth technology which is limited in the range it can cover. Bluetooth operate within 10 meters 360 degree proximity. Bluetooth devices can lose connection in certain conditions, they have week security, poor battery management and slow data transfer.

This design is powered by electric supply from the solar system. It uses DC motors to drive its blades. Its main emphases is to design a system with an adjustable lever system to enable alteration in the height of the blades therefore making it possible to maw the lawn providing different height for the grasses as desired. Main objective is to cut the grass in different heights according to needed requirements.

Electric brush-less motor is used to drive the rotor blade and solar panel is used to drive the motor, while the batteries perform charging and discharging between the solar panel and the motor. The actual mechanism lies between the motor and the rotor using gears for the power transformation. It is designed to be pushed around within the environment to be mowed (Satwik et al., 2015). It uses sets of gears for driving the blades, these gears could be cumbersome to design and unavailable in the market. It cannot be used for any other purpose outside mowing, this reduces its functionality. It could be dangerous to use because of the high voltage it operates with. It also cannot function in regions with epileptic power supply. It cannot be used by minors to avoid electrocution. It is limited in functionality due to the fact that it cannot be used for any other purpose outside mopping. Adjusting the height of the rotor can be difficult and requires extra person to assist, therefore making the machine difficult to operate by one person. The charging system is not effective due to the fact that it will need charging for at least four days before it is used again after battery must have run down. The charging system needs upgrading to enhance the rate of recharge.

Simple Design of Self-Powered Lawn Mower designed by Okafor et al, 2016 is a mechanical lawn mower aimed at supplying its power source by the use of an alternator embedded within the design. This system comprises of a drive mechanism of belts and pulleys which are used to generate a rotational movement, both for recharging of the battery and for mowing the lawn. The movement of the mower is provided by the user. The user pushes the mower any direction and any place he or she wishes to go. It is designed to be self sufficient in terms of power supply. It is pushed around and as such provides rotational movement for driving the alternator and the DC Motor. It is 90 percent mechanical. This design is not user friendly because it is difficult to push around. It cannot be used for other purposes outside mowing. It is complicated to design because it houses sets of gears and belts to convert the rotational movement of the wheels to rotational movement that could drive the alternator. It's belt and pulley system wear out from time to time, and this increases the cost of maintenance. This machine requires a mechanic or the designer to repair any damaged part therefore making it is also difficult to maintain (Okafor et al, 2016).

Smart Lawn Mowers (Derander et al., 2018) is an autonomous robot designed as a prototype for autonomous study of mowing robots. A typical robotic lawn mower (in particular earlier generation models) requires the user to set up a border wire around the lawn that defines the area to be mowed. This robot does not require wires to locate the boundary of the area to be trimmed and in some cases to locate a recharging dock. This machine is sophisticated, it is self-docking and some prototypes are designed with rain sensors if necessary to detect when it is raining so as to avoid water penetrating the device to damage some of its electronic components. This design nearly eliminates human interaction.

This machine operate autonomously with little or no human interference, it uses battery power supply to work (i.e. direct current). They also have sensors that help it make a turn when it comes close at a proximity with an obstacle or a perimeter fence. The battery power of these smart lawn mowers vary with some ranging from 12v 7amps to 12v 14amps. These machines are smart, fast and accurate. Most of them, about 95% are complex to design and maintain. This design faces some challenges, they are not self sufficient in terms of power supply. It could be difficult to maintain. In case of a damaged component, it will not be easy to source material and make the repairs. It cannot be used while it recharges, this makes it difficult to function for a very long time and within a large area (Derander et al., 2018).

The Internal Combustion Engine Lawn Mowers of (Mukhraiya et al., 2018) are machines built with a gasoline combustion engine which provide a rotational movement at high speed and at a very high torque. These lawn mowers are built with an adjustable handle to enable the user push the mower around any corner he or she would want it to go. This machine utilizes one or more blades to cut the grasses of a lawn to an even height, this height can be adjusted to alter the height of the grasses been cut down. This type of lawn mowers as the name suggests uses fossil fuel which is not environmentally friendly as a result of it’s emissions. They are too heavy to be pushed around and cannot be used by the elderly or the physically challenged. They are difficult to maintain and repair. The components are not usually common. They are difficult and complex to design. These machines cannot be used indoors. They emit carbon (iv) oxide which can dangerous to health. They are noisy thereby making them not user friendly (Mukhraiya et al., 2018).

Residential or ride-on mowers (Myers, 2017) also known as a riding mower, a ride-on lawnmower, or a tractor lawnmower is a type of lawn mower on which the operator is seated, unlike mowers which are pushed or towed. Riding mowers, which sometimes resemble small tractors, are larger than push mowers and are suitable for large lawns, although commercial riding lawn mowers (such as zero-turn mowers) can be "stand-on" types, and often bear little resemblance to residential lawn tractors, being designed to mow large areas at high speed in the shortest time possible. The largest multi-gang (multi-blade) mowers are mounted on tractors and are designed for large expanses of grass such as golf courses and municipal parks, although they are ill-suited for complex terrain requiring maneuverability.

Persons using a mower should wear heavy footwear, eye protection, and hearing protection in the case of engine-powered mowers. The American Academy of Pediatric recommends that children be at least 12 years old before they are allowed to use a walk-behind lawn mower and at least 16 years of age before using a riding mower. They also should demonstrate proper judgment and maturity.

The ride on lawnmower has presented risks of serious injury and sometimes death from overturns, crushing injuries, asphyxia, drowning, and fire because they use petrol and gasoline to run it's internal combustion engine. This leads to emission of carbon into the air which is hazardous to the environment. They are noisy. They are driven like power bikes but are not easy to control. They cannot be used by people who cannot ride the machine. Experts are needed to maintain and repair it in case of damage, and this makes it expensive to use. They cannot be used by children, and must be operated by someone which means it cannot be autonomous. It is designed primarily for outdoor purposes and cannot be deployed for mopping floors (Myers, 2017).

User Integrated Semi-autonomous lawn mower system proposed by Patterson et al., 2019 of autonomous system for mowing but stating the limitations an autonomous mowing machine could have and problems which need to be brought into consideration and addressed before an autonomous system can be effectively designed. In their paper they stated that their work is meant to provoke a discussion and interest in the engineering and robotics communities and aid to start developing a standardized and consistent perspective for the future development of refinement of these and other kinds of user-integrated semi-autonomous systems. They insisted their work should serve as a starting place for the research community (both commercial and academic) to improve and develop a systems engineering method for these systems, hopefully culminating in a universal design approach and useful industry standards related to semi-autonomous and autonomous systems in the future. The limitations of this proposal is lack of test courses for the semi-autonomous mowing systems, software and hardware components are not readily available and reliable especially sensors mounted on the robot. It needs special user training program for operating, maintaining, and repairing a user-integrated semi-autonomous mowing system. This suggestion also lacks the robustness of mowing and mopping, and it’s power is not renewable. Mowing robots are subject to more vibration (both regular and unexpected) than other robotic systems the effects of this on performance and reliability is tremendous (Patterson et al., 2019).

An autonomous lawn mower “ManScapper” covers a design for an autonomous lawnmower. The design builds upon a commercial electric lawnmower and adds features to make the process autonomous. The lawnmower uses sensors to avoid obstacles. Computer vision is used to define the mowing boundaries and reference the lawnmower position during use. It uses a microcontroller which stores and manipulates the positional data to determine the path of the mower.

The ManScaper autonomous lawnmower is used to improve the lawn mowing experience with little user interaction. The ManScaper was designed using a commercially available cordless electric mower. The existing lawnmower battery and blade motor system was used to handle the grass cutting function. This machine does not and cannot mop and environment (Cochrum et al., 2013).

Inverter powered lawn mower (Olawale et al., 2019) was designed using an inverter producing 2000 watts, which powers an electric motor of 370W. A 12volt 60ampHr battery is used to provide energy to the inverter. It has the advantage of being rechargeable when it is low and therefore needs no fuel to power the machine. It has no internal combustion and therefore emits no smoke which causes air pollution.

In this project, the battery is connected to the inverter system, and the motor connected to the output of the inverter. When the inverter is powered on it steps up the battery direct current (DC) power to 230v alternating current AC. The inverter alternating current is sent into the motor driving the blade, as the blade rotates, it cuts the grasses under the machine with a speed of about 2800rpm. This lawn mower was designed to mow for a period of two (2) hours and the discharged battery can be recharged with the aid of the inverter when connected to an AC supply. This machine is pushed around the area to be mowed making it 98% dependent on human. This machine cannot capture video or transmit information about its operability over the internet. It is almost a manual machine and cannot be operated remotely. It is expensive to set up because it requires to purchase or build a 2000watts (2kva) inverter with a deep cycle battery (Olawale et al., 2019).

Mobile operated lawn mower (Duppala et al, 2018), is operated with the mobile phone over a network call. In this work, to overcome the limitations imposed by distance in remote controlled lawn mowers, this project is incorporated with a mobile phone which acts as a link between user and grass cutter. Two mobile phones are used in which one acts as a transmitter and the other as a receiver. The transmitter mobile phone makes a call to the mobile phone attached to the circuit of lawnmower. In the course of a call, if any button is pressed, a tone corresponding to the button pressed is heard at the other end of the call. This transmitted tone is called 'dual-tone multiple-frequency' (DTMF) tone. The micro-controller perceives this DTMF tone with the help of the phone stacked in the lawn mower. The received tone is processed by the micro-controller with the help of DTMF decoder MT8870. The decoder decodes the DTMF tone into its equivalent binary digit and this binary number is sent to the micro-controller. The micro-controller is preprogrammed to take a decision for any given input and output. It's decision to motor driver in order to drive the motor forward or backward motion or a turn. The cutter is turned on or off with the help of a mobile phone by a number which is instructed in the program. This method makes it difficult to be used when there is no network, and airtime available. It does not provide room for a display or record of what the machine sees. It also lacks the ability to be smart, it cannot be used as a mopping machine (Duppala et al, 2018).

Autonomous Lawnmower using Field Programmable Gate Array (FPGA) (Ahmad et al., 2016) uses FPGA with GPS navigation. It operates by applying the Global Positioning System coordinate given by the user to move in the area to be mowed. The autonomous lawnmower. A Field Programmable Gate Array (FPGA) is used to control the movements where all data and information would be processed. Very High Speed Integrated Circuit (VHSIC) Hardware Description Language (VHDL) is used to describe and simulate the hardware used in this study.

This robot is expensive to implement. it uses GPS modem which is not readily available and expensive to purchase. This machine also lacks the agility and functionality of performing other tasks outside mowing. It can be difficult and expensive to maintain and repair if damaged. In Nigeria and west Africa at large, the GPS system is not functional for navigation in real time hence limiting the ability and functionality (Ahmad et al., 2016).

2.2.2 Floor Cleaning Machines.

Manually Operated Floor Cleaning Machines are conventional floor cleaning machines available to perform floor cleaning operations. Generally a conventional floor cleaning machines requires electrical energy for its operation. In India, especially in summer there is power crisis, in majority of places. Hence cleaning the floor using the conventional floor cleaning machines is difficult without electricity. In this design an effort was made to develop a manually operated floor cleaning machine so that it can be an alternative for conventional floor cleaning machines during power crisis.

In Pedal Operated floor cleaning machine Ranjit et al, 2015, a pedal operated body is used as the rider machine, on this machine a dry cleaner or a sweeper attachment is made to the front wheel of the body. A frame is constructed for dry cleaning purpose, and on that frame the sweeper is attached. As the machine is ridden, the brushes are turned and the shaft rotates by driven mechanism thereby pushing the dust into the dust chamber attached to the frame. For wet cleaning, wet mops are attached at the rear end of the body, which operates by sliding mechanism on the floor when the body moves, disinfectant liquid is spread just before the mops from a plastic tank during wet cleaning operation. This floor cleaning machine is specifically designed to clean the floors which are plane and smooth, such as tiles and cemented smooth surfaces (Ranjit et al, 2015). This design cannot be used by physically disabled people, and the old. It however was designed for cleaning floors and cannot be deployed outside for mowing. It is not autonomous, and must be operated in all conditions by a rider. It is prone to failure due the fact that it uses a chain mechanism which always fail. It cannot also be used in a small environment.

The remote controlled floor cleaning machine is designed to clean the floor and sweep the dust away. In this module a remote controlled car gear motor is attached at the front axis in between the front wheels, this provides movement for the device to move in the direction needed. The cleaning brush is attached to the motor in front while the gear motor is connected to 12 Volts power and the remote car gear is connected to 9 Volts battery. The remote car gear is controlled by the micro controller, this remote can cover up to 10 meters range in distance. When the remote controlled car gear is operated, the Direct Current (DC) gear motor is manually operated in switch type, the motor runs in clockwise direction at high speed of about 1000rpm and the brush below the motor cleans the floor. This technology uses a remote control for the movement of the machine which results to the movement of the motors driving the mob the floor. (Suresh et al., 2018). This system is powered by direct battery and does not have a means of recharging while in use. With this machine one will have the need to purchase a lawn mower for his compound. This design can also not function without having steady power supply to continually recharge the battery whenever it runs down. It is small in size and does not have room to mop and dry the floor. It contains only the system to brush the floor. It only function well in a smooth surface. The system cannot withstand environmental pressure.

Automatic floor cleaner (Vignesh et al, 2019) is a system that enables cleaning of the floor by the help of highly stabilized and rapidly functional electronic and mechanical control system. This machine automatically navigates itself. Although it's functionality is limited to only mopping floors, but lack of steady power supply makes it difficult to function. It uses a programmable micro controller to make decisions which helps it navigate the environment it is meant to clean and mop. This machine is not integrated with a mowing capability, even though it might be rechargeable it doesn't generate its own electricity and therefore cannot function if it is used in an area with limited power supply. This machine uses a controller and a remote. It uses Alternating Power supply and gets its power supply from a wall power outlet. It's drive mechanism is through a set of Alternating Current (AC) driven motors, and the mopping features are connected to an AC motor which provides the rotational movement needed to brush and scrub off dirt on the floor (Vignesh et al, 2019).

It could be dangerous to use because of the high voltage it operates with. It also cannot function in regions with epileptic power supply. It cannot be used by minors to avoid electrocution. It is limited in functionality due to the fact that it cannot be used for any other purpose outside mopping. Because of the long cable attached to it which is plugged on the wall, it pose a serious health challenge because the cable drops on the floor and can be dangerous to the user and people around.

Wireless multi-purpose floor cleaning machine by Patel et al., 2019 is capable of performing cleaning of floor and corners effectively. It is designed to dust, vacuum clean, and floor clean simultaneously. This machine is designed to be powered by battery. It is light weight and therefore gives high torque for the cleaning and movement actuators. This system is limited in certain ways: It is not multi-functional as the name suggests because it does not have within its design room for other purposes outside mopping, and its mopping capability is hindered because it cannot wet and dry floors for efficient and effective cleaning. It cannot be used in countries were steady power supply is a problem (Patel et al., 2019).

Floor Cleaning machine designed by Ghaffar et al, 2018 was developed to function in all seasons of the year including in the raining season. It’s main purpose is to work in a way as to dry the floors during or after rains. It is not only meant to function indoors, but can also function in a tiled outdoor environment. It is an effective system for mopping in winter, summer and raining seasons. The machine uses an Alternating power supply from the mains power outlet, this AC power is converted to direct current power which is used to power the electrical motors that mop the floor. This machine has a power adapter within its design. This adapter converters the alternating power supply from the power source to direct power supply which is needed to drive the motor assembly. As the motor revolve, there is a pulley and a belt system that transfers the rotational movement of the motor to the pulley which also transfer it’s movement to the set of brushes that brush and the floors. This design is also pushed around within the area it is deployed. It needs human assistance at all time to function. This design is not user friendly, and cannot be used by physically challenged persons. It requires physical manpower. It is slow and cannot cover a large area in a limited time interval. It uses power supply from a mains power source which is not readily available in this part of the world. It has long cables which drop on the floor posing a serious treat of electrocution. It will need a very long cable to mop a large area. Sometimes long cables can entangle to even limit the movement of the machine therefore limiting the functionality of the machine. Pulley and belt systems usually wear out, with this frequent changing of belts is a problem. Worn out belts can twist around the drive motor causing damage to the motor or the brushes (Ghaffar et al, 2018).

Pedal operated floor mopping machine is a pedaling machine modernized with mopping equipments attached to it. It is pedaled and driven like the normal bicycle. This device is manually operated. It has gears and brushes attached below the pedal system, it also houses a water tank behind the user on the load sit which can supply disinfectant water to the brushes below the machine. This aids the brushes to mop and as well disinfect the floors. As the machine is pedalled by the operator, the machine moves but this time it moves slowly. The pedaling provides a rotational movement for the set of gears attached to the pedal system. This rotational movement is attached to the brushes which as well rotate thereby providing the cleaning needed to be done on the surfaces. The water tank behind the rider wets the floor while the brushes connected to the pedals rotate creating a 360 degree movement which brushes off dirt on the floor.

This design cannot be used by someone who does not know how to ride a bicycle. It cannot be used by physically challenged or old people. The pedalling effort needed to drive the mechanism with the loads on it is high. Reconstruction of a bicycle to get a desired and functioning system could be cumbersome and difficult (Ghosh et al., 2016).

This machine has no system for drying a mopped area, this can be accidental to anyone around or to the machine. It has limited weight it can carry, this makes it impossible for people whose weights are higher than that stipulated for the machine to use and pedal.

MI Robot Vacuum-Mop P is an AI driven home cleaning device. It is equipped with 12 different multi-directional sensors. The smart vacuum cleaner also has a Laser Distance Sensor (LDS) navigation system to scan the environment and navigate through hurdles during the cleaning process. The vacuum-mop comes with a quad-core Cortex-A7 processor. It is powered by an anti-collision sensor, an anti-fall sensor coupled with Laser Distance Sensor navigation based on Simultaneous Localization and Mapping algorithm. This device has a lithium battery that enables it to perform up to 110 minutes of cleaning. It has an electronically-controlled water tank that comes with three gears of water for different floor materials. The device is immobile when it runs out of water owing to its outlet sensing technology. The smart appliance has a brushless motor.

The Mi Robot Vacuum-Mop P has built-in Wi-Fi capability. Users can enable smart control for the cleaning device by connecting it to the Mi Home app. They can view the virtual Map that the vacuum sees from the app. This machine does a good job in the cleaning floors using it's vacuum, but it lacks the functionality of mowing, it is expensive and complex to design and maintain (*Mi Robot Vacuum Mop Pro Mi Robot Vacuum Mop P （LDS Navigation）*, n.d.).

The Next Generation Autonomous Lawn Mower (Chandler et al., 2000) is a project which was designed and implemented at the university of Florida. It is built to mow an environment intelligently. It is equipped with computer technology and machine learning techniques to enable it accomplish tasks a smarter way. This machine uses Linux operating system (OS) to run and process information gathered by the on board microcontroller for processing and executing of instructions. Using a Linux operating system computer makes the system fast and agile when it comes to decision making, and has large memory. The project has the challenges of learning its environment and it can take considerable amount of time to teach it either under supervised learning or unsupervised learning.

The machine is specifically designed to mow and cannot mop floors. It is difficult to maintain as its machine learning codes are too long and cannot be serviced by someone who is not a professional. It cannot identify objects, its parts are specially manufactured making it expensive, it also cannot avoid obstacles (Chandler et al., 2000).

2.2.3 Embedded Robust Visual Obstacle Detection on Autonomous Lawn Mowers:

This project inculcates computer vision into a lawn mower giving it an ability to see it's environment and avoid obstacles. This project is a prototype autonomous lawn mower with camera-based non-contact obstacle avoidance. They devised a low-cost compact module consisting of colour cameras and an ARM-based processing board, which can be added to an autonomous lawn mower with minimal effort. On the software side they implemented a colour-based obstacle avoidance system, this system uses colour of grasses which is mostly green as its reference colour, and it avoids tries to avoid objects which are not green in the field. This is done through a camera control that can deal with the challenging outdoor lighting conditions (Franzius et al., 2017).

2.3 Surveillance Technologies

Intelligent Video Surveillance Technology in Intelligent Transportation focused on intelligent traffic video monitoring technology, it aims at understanding and analysing using intelligent video monitoring the causes and sources of urban traffic pressure. To achieve this, this study uses video surveillance system to study and realize video tracking of people and vehicles moving in traffic, and this must be determined first, using detection technology in camera programs. Object detection technology is used to detect objects mostly in motion, this is different from static image analysis although they share some similarities. Motion detection of an object or a target is done by dividing the picture into motion intervals and the static interval, and then analysing the continuous image change, the structural features of the moving target is extracted and analysed to judge the state of the dynamic target. The result obtained is used to determine if there is motion or not, and with further analysis determine what object it is, the size, and type of motion (Fangcheng He, 2020).

Zigbee Controlled Multi Functional Surveillance Spy Robot for Military Applications focused on an electro-mechanical machine controlled either by a designed computer program and with electronic circuits. This robot is targeted for saving human life. It could be deployed in the battle field to work and assist soldiers. The system is a multifunctional robot developed with Zigbee and by using Arduino microcontroller for military purposes only. The Zigbee Arduino robot has limited programmable memory, it is not flexible and cannot be reprogrammed as needed with ease. It may find it difficult to function in harsh environmental conditions, and runs on low battery power. It is strictly for surveillance in a limited environment and cannot operate for a long time (Rani, 2020).

Intelligent Surveillance Robot with Obstacle Avoidance Capabilities Using Neural Network, the study proposed an intelligent surveillance robot for disaster management environment using camera and face recognition technology. The project uses ultrasonic sensors for obstacle avoidance and navigation, it also uses neural network for the camera system. It operates with 2.4GHz to transmit videos to the operator or user to enable direction of the robot to the desired area. This project has single functionality and cannot be used for anything outside surveillance, it is limited in functionality and cannot mop floors nor mow a lawn. It is not self sufficient in terms of power generation and cannot also work for a long time without recharge (Budiharto, 2015).

Surveillance Robot for Defence Environment focused on a practical present-time approach for surveillance robots at a remote location probably an enemy territory which may not be safe for trespassing, this system uses a remote control based robotic vehicle using wireless technology at a frequency restricted for defence and military. The system has sensors and cameras which are used to detect and identify human, IED’s, objects etc. This system designed and developed to work in an unfavourable environment or area with better efficiency. This system can be deployed to determine the number of terrorists in buildings with hostages. The processing unit of the proposed system is the Raspberry pi using a raspberry operating system and programs which could be reprogrammable on board and on demand. The on board computer controls the movement through the raspberry pi general input general output pins, information is gathered through the onboard sensors and cameras (More et al., 2019).

This system is restricted because it is primarily for the military and operates with frequencies restricted for military use. It cannot be commercially available for the public, it has a high degree of accuracy in surveillance but zero functionality in mopping or mowing an environment.

2.4 Research Gap

The reviewed machines have been designed and developed to carry out specific functions. They are designed with unique features, but non has been designed to be intelligent, multitasking and smart. No lawn mower has features of a mower and a mopping machine with the smartness and ability to use machine learning capabilities. Reviews conducted with respect to similar works done shows that no mopping machine or mowing machine can serve its purposes and do the work of monitoring an environment. Already existing machines are not Eco-friendly (renewable energy) with zero emissions, stress free and fun to use, autonomous or remote controlled as desired and above all have the capability to mop, mow and serve some security purposes at anytime, and any day without issues.

Machine localisation and identification of its environment with respect to itself is a feature yet to be addressed, Power supply challenges are to be addressed, charging rates, autonomy, easy control of the machines, reduction in emission rates are addressed within this design. Surveillance of an environment to provide security information or clue about an environment is made possible with the machine implementation.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Materials

Software Materials:

Autodesk AutoCad 2022

Python Programming languages

C++ Programming Language

PIC Basic

Proteus Design Suit

Hardware Materials:

i. Raspberry Pi
ii. Cameras and Universal Serial Bus
iii. Capacitors
iv. Resistors
v. Relays
vi. MOSFETS
vii. Ultra-sonic sensors
viii. Radio Transmitters and Retrievers
ix. Solar Panel
x. IC’s and IC sockets
xi. Batteries
xii. Diodes
xiii. Electric motors
xiv. Cooling fan
xv. Iron Blade
xvi. PVC, and Brushes
xvii. Iron Pan
xviii. Rubber – Polymer tires

3.2 Methods

In order to achieve this study, a top down design approach was used. The mechanical subsystem designed involved drive mechanism for the robot mowing and mopping assemblies. The drive system encompasses electric motors which are embedded with a set of gear system, the connecting rods, and the tires. The mowing section involving the blade, and the drive motor, and mopping assemblies which involve the brush for scrubbing, the PVC liquid container and piping system, the dry assembly and the system cooling motor and fan.

The electronic system encompasses the power subsystem controlling power supply through solar panel and alternating power source, the radio communication subsystem which include the RF transmitter and receiver module encoded and decoded with the encoder and decoder chips, the micro-controller subsystem which is programmable.

The computer system has the on board computer which houses the hardware and software section of the robot. The hardware include but not limited to the camera system, the memories (RAM, ROM), General Purpose Input Output (GPIOs) subsystem. The software include a Raspberian Operating system, C codes for autonomous navigation, PIC basic programs for remote control, and python programs for camera.

These aid robot navigation and control of the machine. Fig. 3.1 is the block diagram of this mopping, mowing and surveillance robot.

SYSTEM BLOCK DIAGRAM OF THE ROBOT

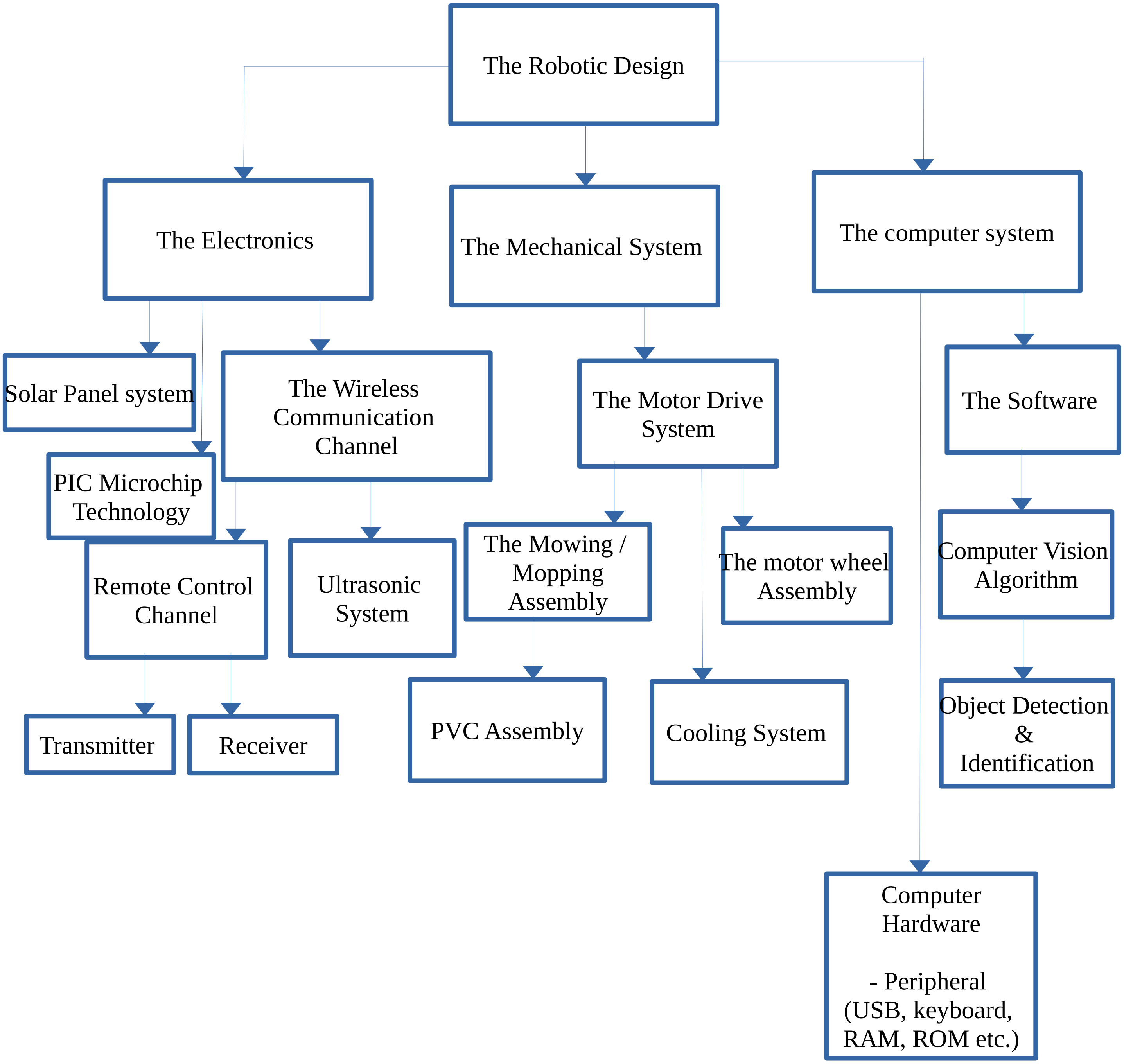


Fig 3.1 Robotic Block Diagram

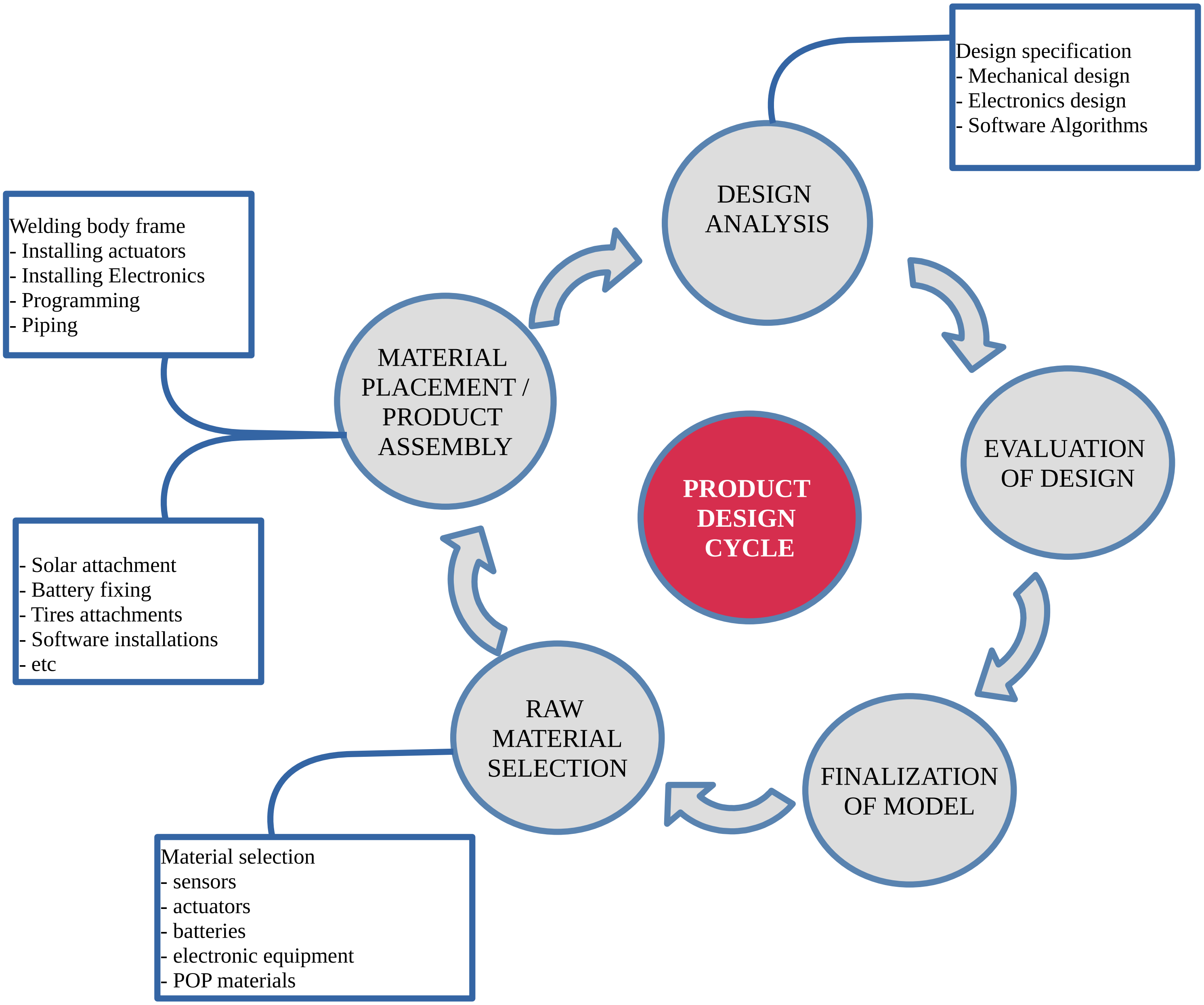


Fig 3.2 Product design cycle

3.2.1 Development of drive mechanism for mopping, mowing, and surveillance (The Mechanical System)

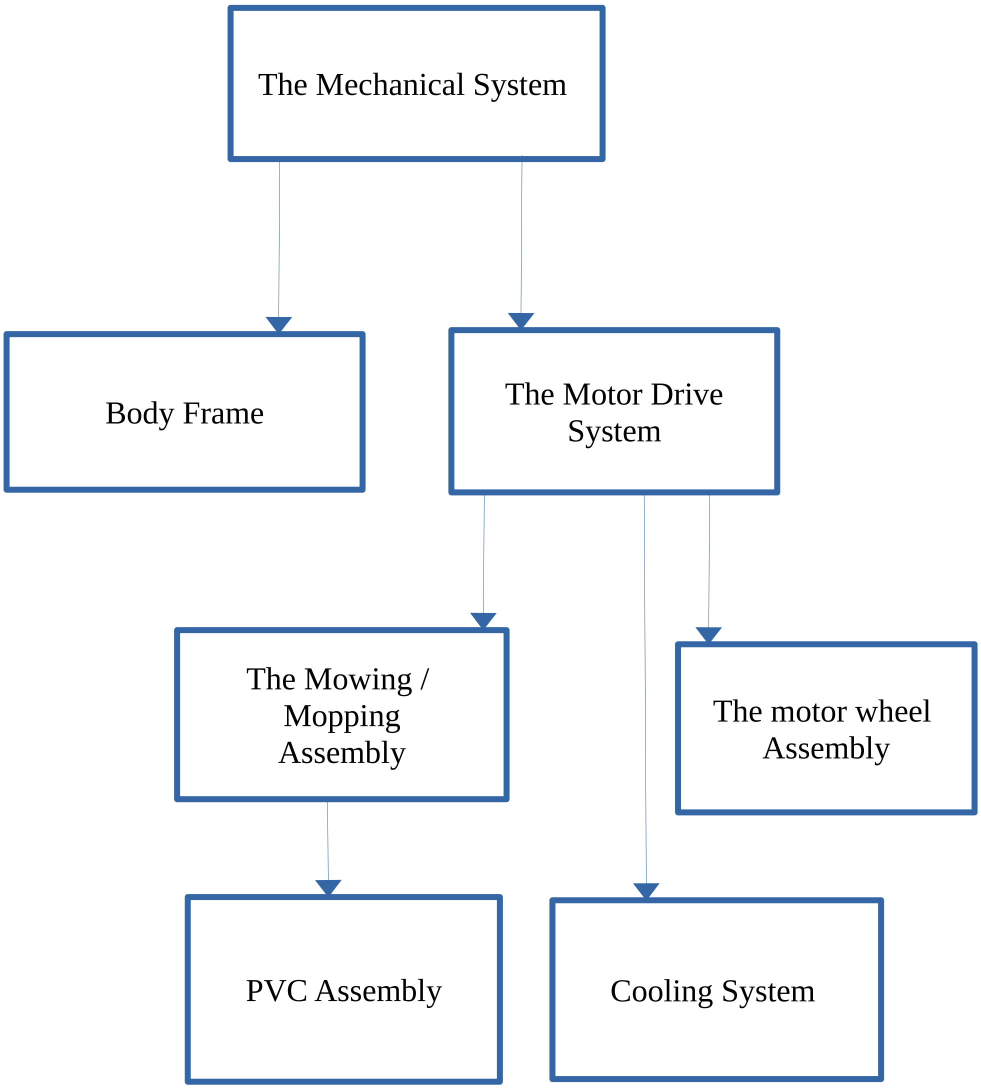


Fig 3.3 Mechanical subsystem of the Robot

The Software design of the robot was done using the AutoDesk AutoCad 2022 software. The implementation was carried out by a welder under my supervision and direction. An expert welder was needed for welding, cutting and filling, this required moving to a welder's workshop to borrow his machines and his assistance for the welding work. An electromechanical gear was constructed for the drive system.

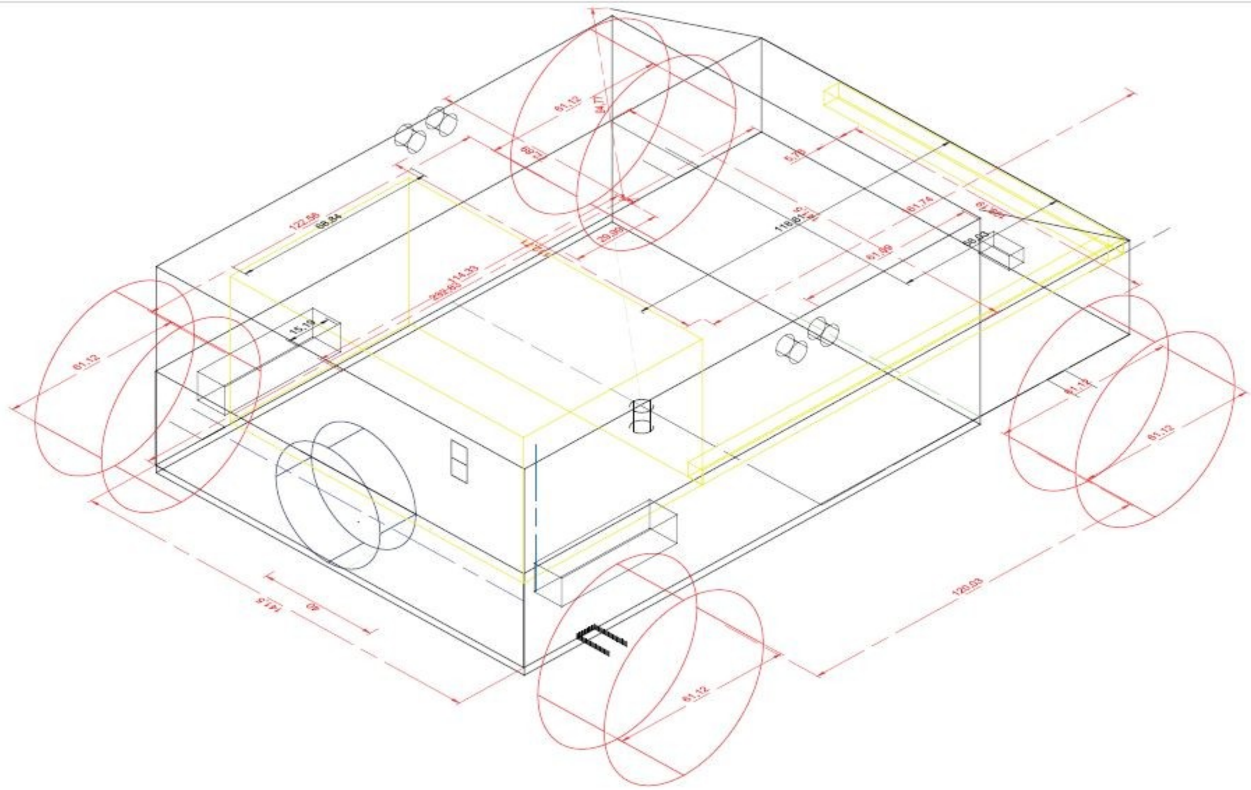


Fig 3.4 Schematic diagram of the robot

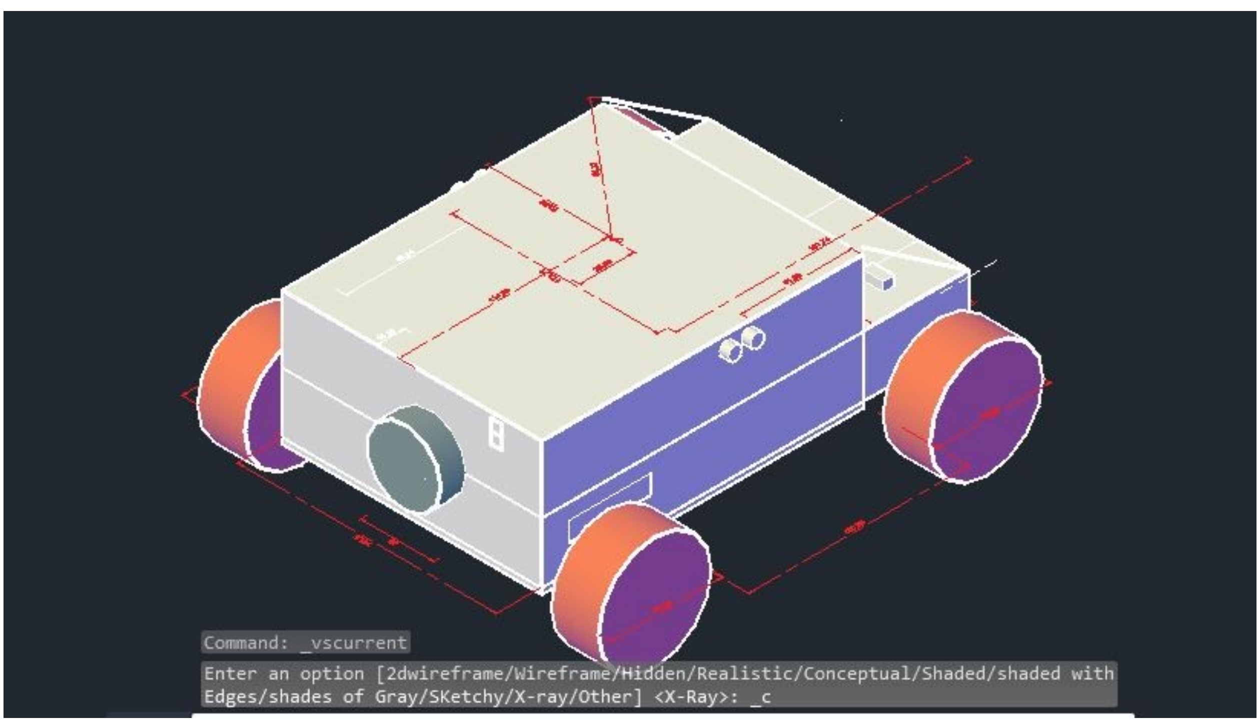


Fig 3.5 Conceptual View of the robot

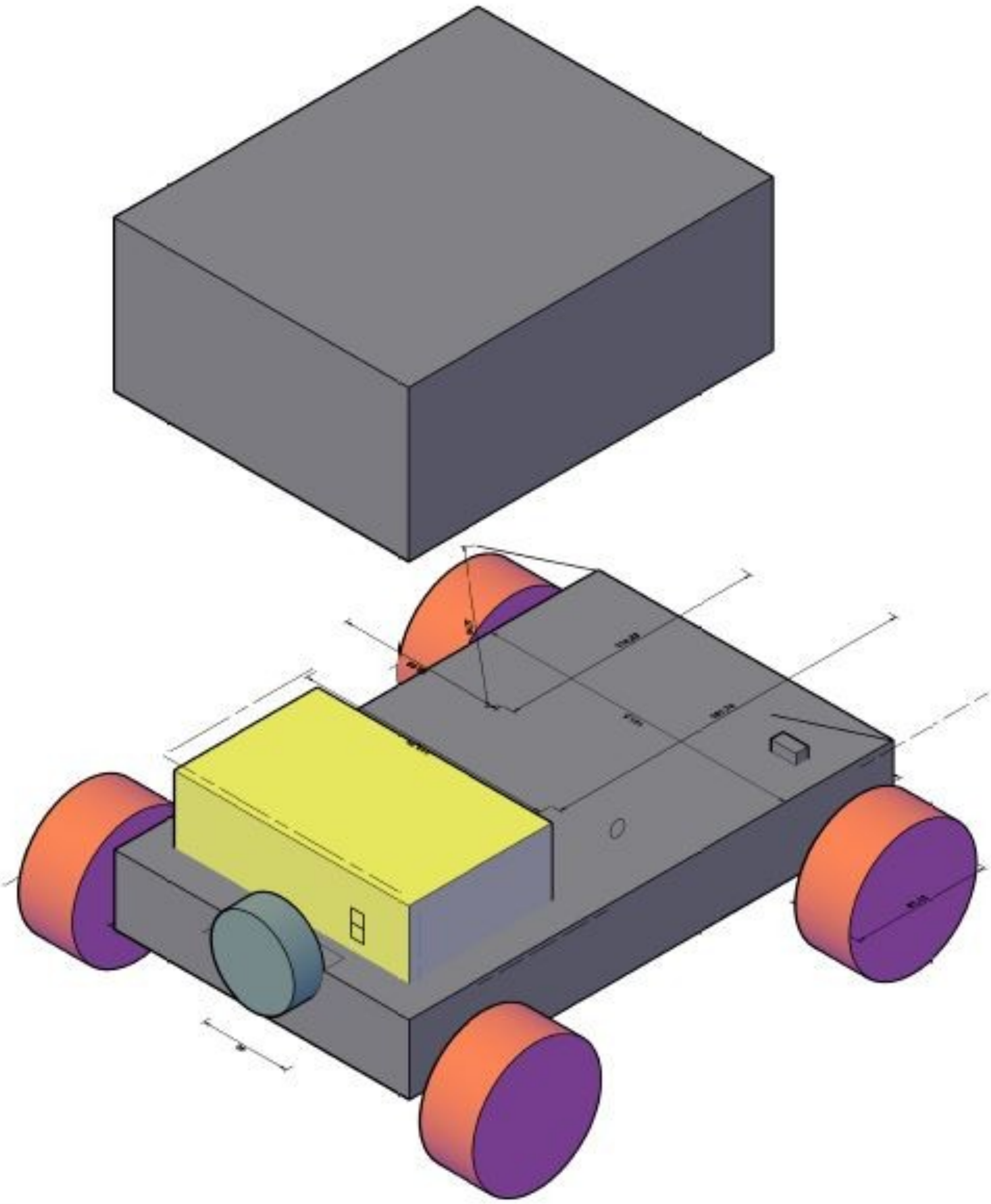


Fig 3.6 Conceptual View of the robot

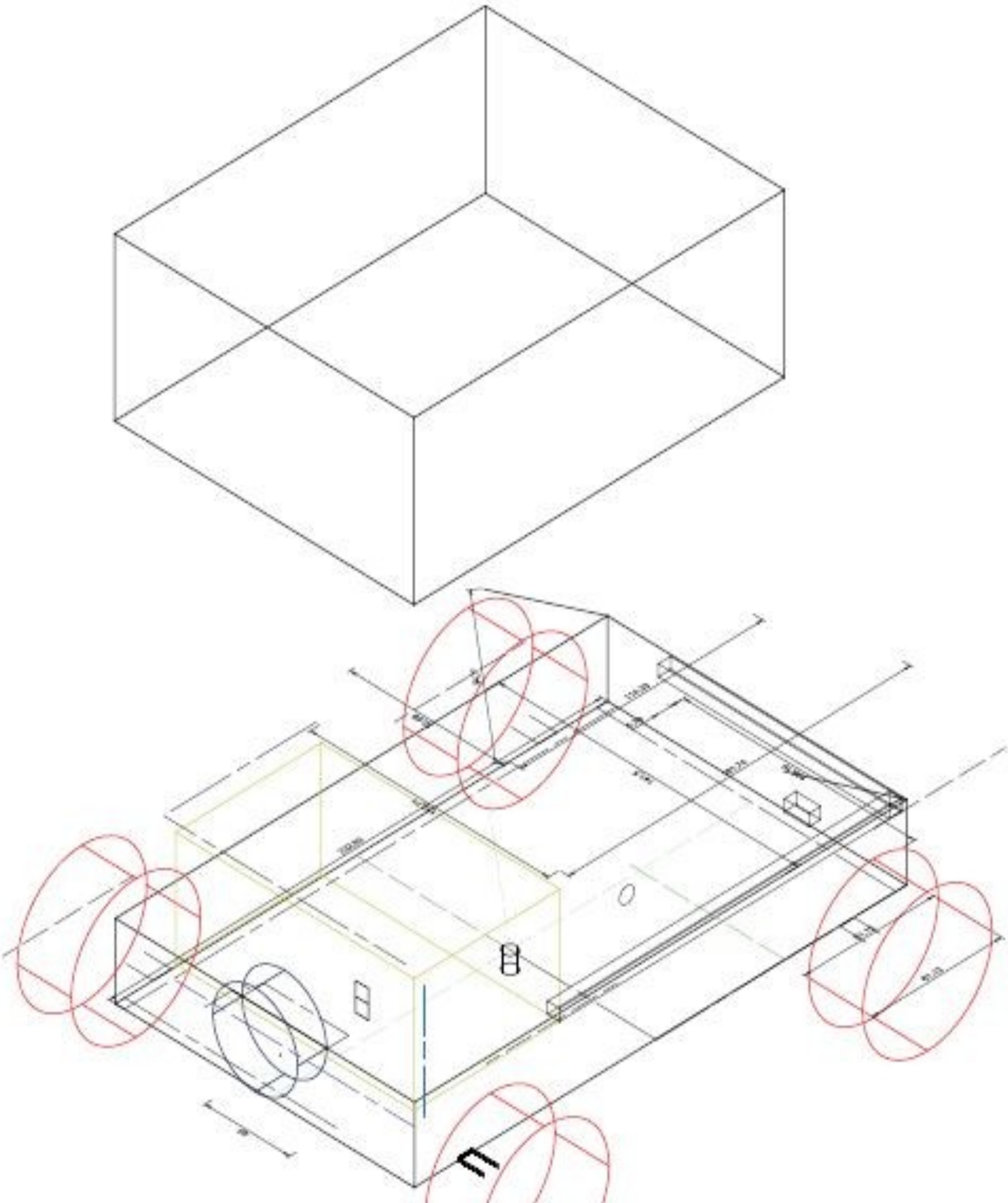


Fig 3.7 Schematic Diagram of the robot

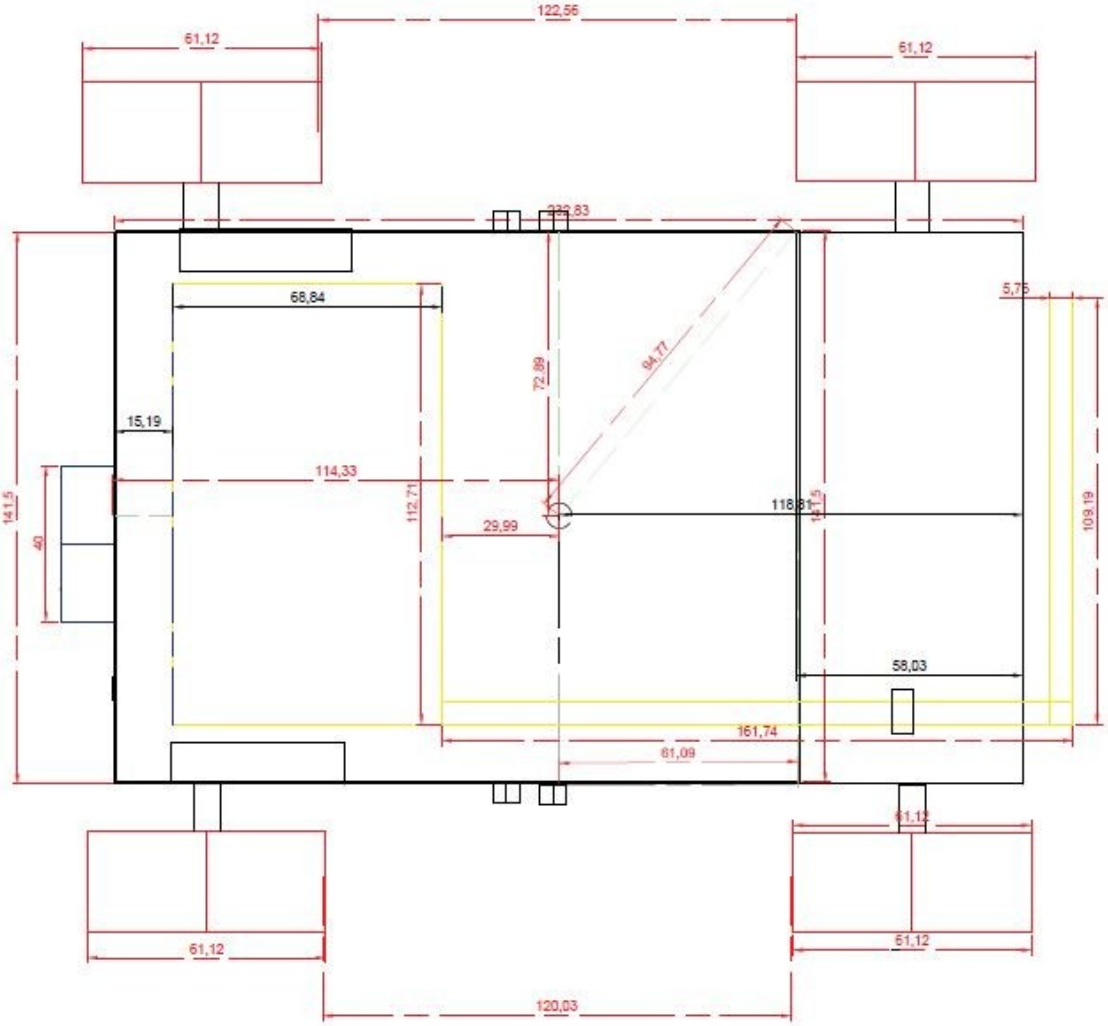


Fig 3.8 Top Schematic View of the robot

Table 3.1 Mechanical specifications

Iron case	**Specification**
Thickness	3mm
Dimension	300mm x 300mm
Top cover Iron Case	**Specifications**
Thickness	1.0mm
Dimension	300 mm x 300 mm
Height	150 mm

(Measurements from components)

Table 3.2 Actuator specification

Motion Actuators	**Specification**
Rated Speed	60 ± 15.0RPM
Current (No Load):	5.0 A
Rated Current (Load)15A	15.0 A
Stall Current (Locked)	28.0 A at 12.0 V
Rated Torque	30.0 Kg.cm (2.9N.m)
Stall Torque (Locked)	100 ± 15Kg.cm (~10N.m)
Motor weight	696.0 g
Mopping / Mowing actuator	**Specification**
Motor	775 Ball bearing DC MoTOR
No load Speed	12,000 RPM at 12V
Weight	350g
Rated current	1.2A at 12v
Operating Voltage	9.0 V – 24.0 V

(Handson Technology 2022)

Table 3.3 Component Specifications

Liquid container	**Specification**
Volume	1 litre
Material	Plastic

Brush	**Specification**
Dimension	150 mm x 40 mm
Height	40 mm
Material type	Rayon Nylon inter-weaved
Mop	**Specification**
Dimension	600mm x 70mm
Material Type	Cotton / Fore
Blade	**Specification**
Material	Iron Bar
Thickness	1.5mm
Length	180mm
Width	25mm
Tire	**Specification**
Dimension	150 mm
Thickness	30 mm
Material type	Rubber
Cooling	**Specification**
Dimension	100 mm
Thickness	30 m
Material type	Rubber

(Measurements on physical components)

The body specification and design required was achieved to house the electrical, mechanical and other components of the machine. The Iron Body (Metal Case) is a 1.5mm thick Iron pan that could withstand some environmental pressure and weight load of the materials used to build the robot. The machine weigh an average of 18 kilogram, and weighs less when mowing due to the fact that it has no liquid within it's internal water container. It weighs a little higher than 18kg when one litter of water is poured in for mopping. The iron body is drilled and welded at different required points and ports to give room for other parts of the robot such as the drive system for the wheels and electric switches and cables to pass through. The drive systems are the motor actuators. These actuator motors are Direct Current (DC) based motors, and it is the mechanism used for the movement of the robot and the rotation needed for mowing and mopping. The DC motors rotate when current flows through them thereby providing the rotational movement required to drive the robot.

3.2.2 Development of Radio communication channel for robot navigation using Wi-Fi and internet, Radio Frequency and Ultrasonic (The electronics subsystem)

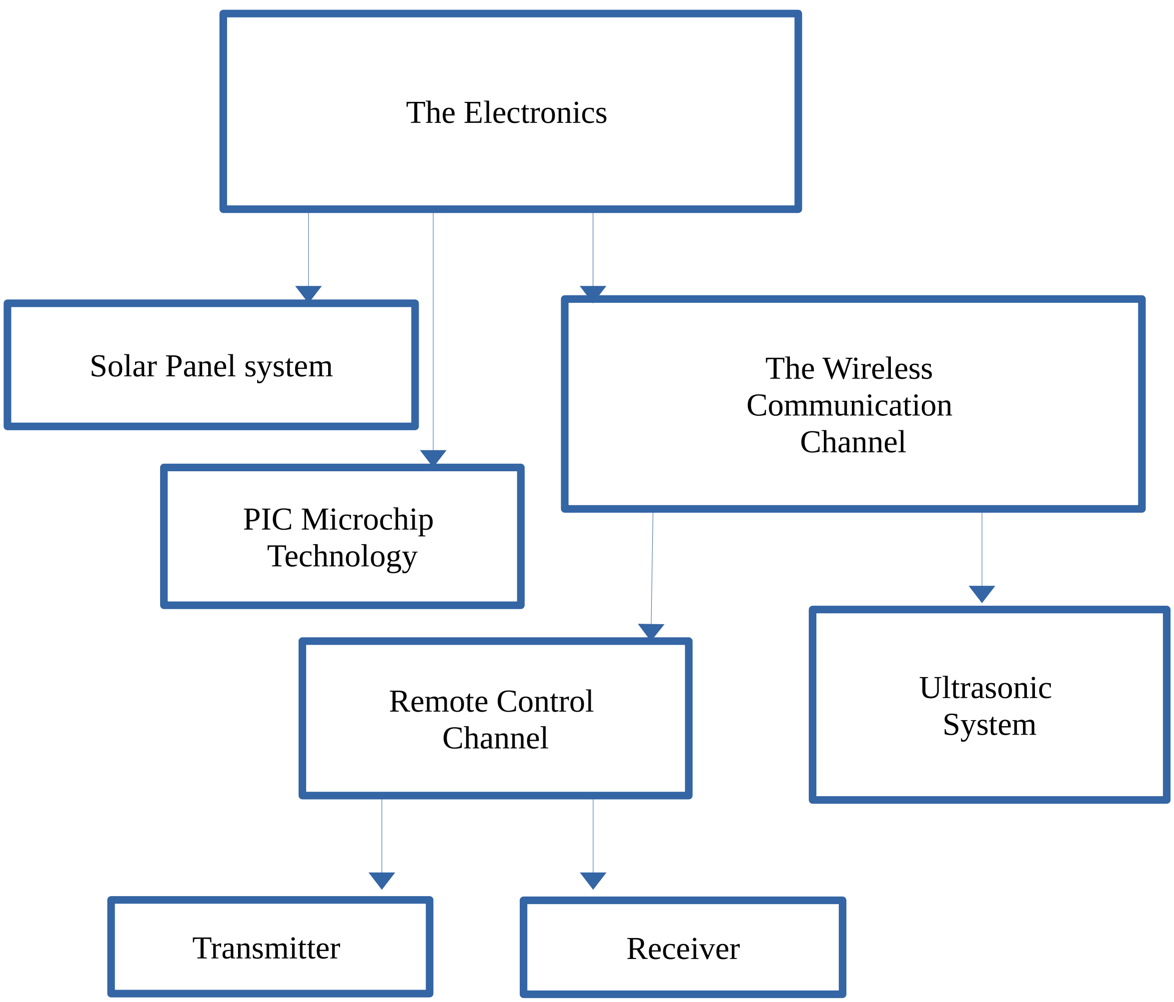


Fig 3.9 Electronic subsystem of the Robot

Table 3.4 Electronic communication specifications

Communication Devices	**Specifications**
HT12 encoder	HT12E
Operating Voltage	3-12V
Current	300mA
Operating Temperature	-50deg to 75deg
HT12 Decoder	**HT12D**
Operating Voltage	5.0 V
Current	300mA
Operating Temperature	-50deg to 75deg

(Holtek 2009)

Table 3.5 Ultrasonic sensors specifications

Ultrasonic Sensors	**HC-HRO4**
Operating Voltage	5.0 V
Max Range	4.0Meters
Min Operating Distance	20 mm
Working frequency	40.0Hz
Measuring angle	15.0 degree
Working current	15.0 mA

(Elec Freaks)

Table 3.6 RF Transmitter Receiver specifications

RF Transmitter	**XD-FST**
Operating voltage	3.5 – 12.0 V
Transfer rate	4.0 KB / S
Transmitting Frequency	433.0 MHz
Max. Distance	20.0 Meters
Transmitting power	10.0mW
Dimension	19.0 x 19.0 mm
RF receiver	**XD-RF-5V**
Sensitivity	-105DB

Operating Voltage	DC 5.0 V
Receiving frequency	433.92 MHz
Current	4.0 mA
Size	30.0 x 14.0 x 7.0 mm

(Components101)

The computer is linked to the onboard transmitted used to control the direction of the machine. When the transmitter is powered on, it sends signals to the receiver which relays to the microcomputer onboard. This microcomputer automatically switches to remote control mode. The micro-controller then analysis the signals from the buttons to make decision on which pin of the chip to activate. When a pin connected to the transmitter is activated, the transmitter gets a LOW (0 Volts) signal, this activates the transmitting section making it possible for the receiver to get the instructions and make appropriate decision based on the instructions received. The transmitter and receiver are active high devices but use low signals to function. This low signals are manipulated with proper coding and electronic circuits to enable its use as intended.

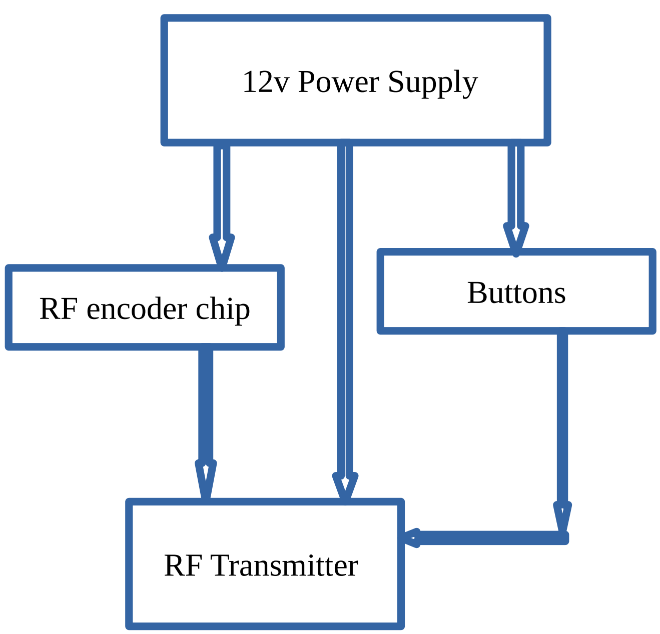


Fig 3.10 Transmitter Block Diagram

At the receiving section, the radio receiver intercepts the radio frequency of the transmitter and the RF decoder decodes the signal transmitted, while this happens the micro-controller makes decisions based on the decoded signal. The decision could be to work autonomously or to activate manual control of the device.

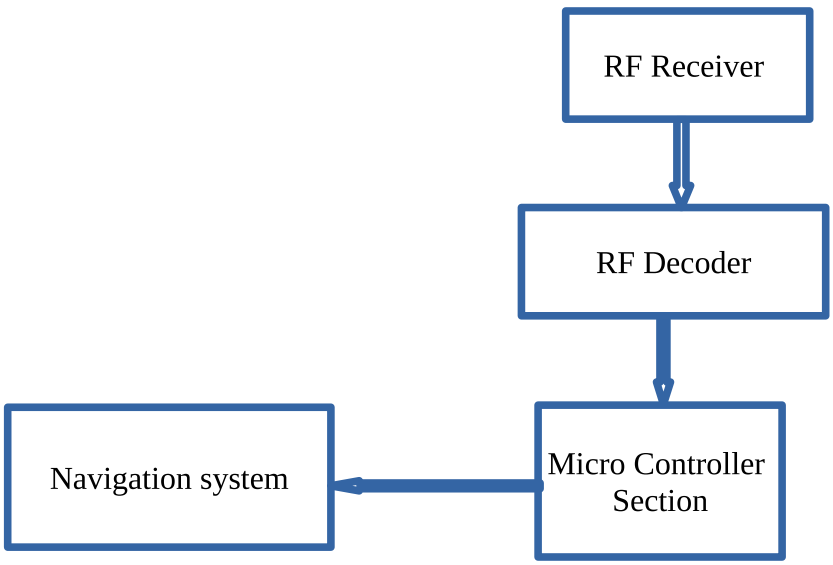


Fig 3.11 Receiver Block diagram

The Ultrasonic communication system aids the robot navigate its way through the environment it operates. The ultrasonic sensor is used to pinpoint the position of the robot in a confined environment. The sensor transmits sound waves and when this sound wave hits an object and bounces back, the robot measures the time it took the echo to get back to the robot. With this, the robot calculates exactly the distance the obstacle or object is from itself.

$$Sound\ speed = 340\ m/s$$

$$time = distance/speed$$

$$Round\ trip\ time = time\ x\ 2$$

$$distance = (speed\ x\ time)/2$$

(RF Wireless World, 2022)

Ultrasonic sensors have three broad categories: transmitters, receivers and transceivers. Transmitters convert electrical signals into ultrasound, while the receivers convert ultrasound into electrical signals, while transceivers can transmit and receiver ultrasonic signals. The HC-HRO4 transducer is used in this project to determine the distance of an object from the robot preventing it from colliding with objects within the environment where it is deployed for use. This sensor operates at a frequency range of 25kHz to 50kHz and operates with 5 Volts DC power supply. It has 4 pins – the “VCC” which is for power supply (5 V), the trigger pin which is an input pin to the sensor from the microcontroller. The trigger pin of the sensors are connected different ports and pins of the microchip, for instance the front sensor is connect to pin 0 of PORT D of the microchip and is controlled by the program. The trigger pin of the sensors are set high for at least 10us (10 micro seconds) to initialize measurement by sending the ultrasonic wave. The Echo pin is the output pin of the sensor, this pin goes high for a period of time which is equal to the time taken for the ultrasonic wave to return back to the sensor. The final pin is the ground pin which is connected to the ground of the sensor.

3.2.3 Development of Power and Electronic Systems for the robot mopping, mowing and surveillance:

Table 3.7 Power devices and specifications

Electronic Power devices	**Specifications**
Solar Panel	350 x 400 mm
Power ratting	18.0 V
Current	1.22Amps
Power rating	22Watts
Battery	**Panasonic 7.2Amps**

Voltage	12.0 V
Current	7.2 Amps x 3
Transformer	**12v – 0 – 12v centre tapped**
Voltage	24.0 V
Input Voltage	120 – 240 V
Current	500mA
Diodes	1N4007
Current	1.0 Amp
Max Voltage	1000V

(Specifications on components)

Solar Panel or Photo-voltaic cells absorb sunlight as a source of energy. This panel is made up of photo-voltaic cells which generate direct current (DC) from the solar radiation of the sun. This Photo cells are combined in series and parallel within the panel system to generate 22 Watts of current and 12 Volts needed to drive the robot and as well recharge the battery. The Lead acid rechargeable battery in the machine (robot) stores the energy from the panel and uses it to power the machine. This battery provides direct current power supply to electrical gadgets. This serves as alternative to solar power in areas of dim light or when functioning at night. Three lead acid batteries are used and connected together in parallel. Each battery has a capacity to store 12 Volts 7 Ampere Hour.

Energy from battery

$$P = V \times I \qquad (3.1)$$

Note:

$Battery\ Voltage(V) = 12\,V$

$Battery\ current\,(I) = 7.2\ Amps$

Battery wattage (P) for each battery

$$P = V \times I \quad = \quad 12 \times 7.2 = 86 \quad \text{Watts}$$

Total energy supplied by the batteries = $86.4 \times 3 = 259.2$ Watts

Power Generation (Solar)

From equation 3.1

$P = V\,x\,I$

Therefore $18\,V\,x\,1.2 = 22\,Watts$

Ultrasonic Sensor:

$Working\,voltage = 5\,V$

$Working\,current = 15\,mA$

Power consumption:

$P = V\,x\,I$

$P = 5\,V\,x\,15\,mA = 0.075\,Watts$

Radio Frequency Receiver and Transmitter Modules

Receiver module:

$Operating\,Voltage = DC\,5\,V$

$Current = 4\,mA$

$Power = V\,x\,I$

$P = 4\,x\,5 = 0.002\,Watts$

Transmitter Module:

$Operating\,voltage = 3.5 - 12\,V$

$Transmitting\,power = 10\,mW$

$Total\,Power = 12\,x\,10\,mW = 0.012\,Watts$

The RF Decoder and encoder chip

Encoder Chip:

$Voltage=5\,V$

$Current=800\,uA$

Decoder Chip:

$Voltage=12\,V$

$Current=300\,uA$

Power for the encoder chip:

$P=V\ x\ I$

$P=5\ x\ 800\,uA=0.004\,Watts$

Power for the decoder chip:

$P=V\ x\ I$

$P=12\ x\ 300\,uA=0.0036\,Watts$

Actuators:

$Maximum\ current=10\ Amps$

$Maximum\ voltage=15\,V$

$Maximum\,Torque=7\ Nm$

$Power=10\,x\ 15=150\,Watts$

Raspberry PI

$Voltage=5\,V$

$Current\ consumption=600\,mA$

$Power=5\,x\,600\,mA$

$P=3.0\,watts$

Estimated power usage from other electronic components (Microcontroller, Relays, MOSFET, Resistors) = 5 Watts

Estimated Total Power usage (watts) per Hour = Ptotal = P1 + P2 … Pn (3.2)

$$= \quad Ptotal = 0.075 + 0.002 + 0.012 + 0.004 + 0.0035 + 150 + 3 + 5$$

$$= \quad 158.0965\, Watts$$

Table 3.8 Microchip specifications

Microchip	**Specification**
Micro-controller	PIC 16F877A
Current	300mA
Operating Voltage	4.5V – 5.5v
External Clock	4 MHz
Programming language	PIC Basic
ROM	8KB
Pinout	40 Pins

(Microchip technologies)

Table 3.9 Relay specifications

Relay	**Specification**
Type	HASCO
Operating Voltage	14 V
Max. Conductor Voltage	260 V
Max. Conductor Current	10Amps
NC	14V 15Amps
NO	14V 20Amps

(Hasco relays)

Table 3.10 Transistor specifications

Transistor	IRFZ44
Gate source Voltage	60 V
Drain source voltage	+-20 V
Max Power dissipation	150 Watts

(Vishay Mosfet)

Table 3.11 Voltage Regulator specifications

Voltage Regulator	7805
Operating Voltage	0 – 7 V
Max current	1 Amp
Voltage Regulator	7815
Operating Voltage	0 – 18 V
Max Current	1 Amp
Capacitors	25V 100uF

(Vishay Siliconix)

When the power is generated through the panel and the batteries connected, it's voltage output is regulated with a voltage regulator. A voltage regulator as the name implies is designed to automatically maintain a constant voltage level. The 78 series of voltage regulator is deployed within the robot. 7815, is connected to supply power of 15 Volts used during charging, the 7812 and 7805 supplied 12 Volts 1 amp to the relays driving the motors and 5 Volts 1 amp to the other electronic components respectively. The 7805 is connected to reduce the voltage for the micro-controller section. The micro controller uses a designated voltage of 5 V.

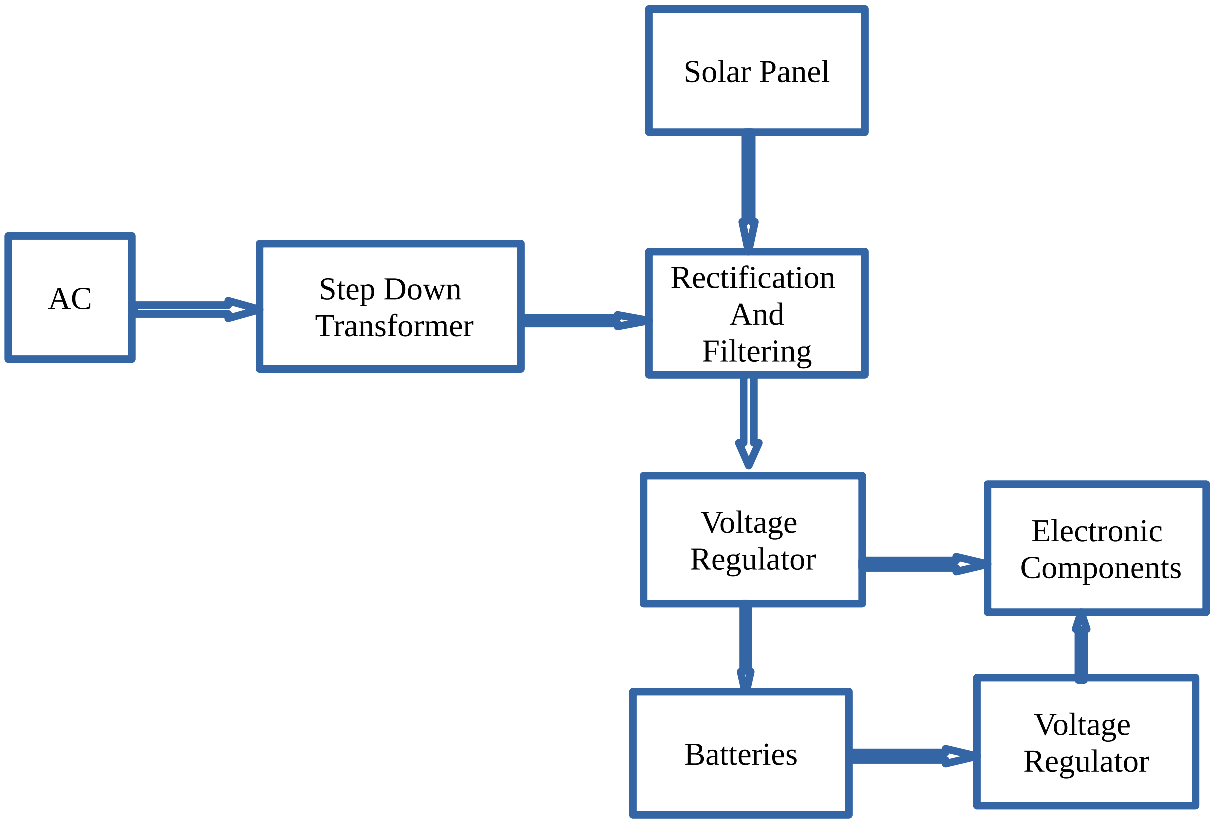


Fig 3.12 Power supply block diagram

Power was also sourced from mains power supply (PHCN) to provide an alternative power source for the battery charging. To actualize this, a power pack was designed for mains alternating power supply. This include a step down transformer which was used to step down the power from a 220 V alternating current to 24 V alternating current. The 1N4007 diode tolerate up to 1000 V alternating current was connected to the output of the transformer. The diode is an electronic component with two-terminals and conducts current primarily in one direction. The diodes used were used to convert alternating current (AC) to direct currents (DC), this gave room for the charging of the system batteries using alternating current. At this point, the capacitor was connected to the rectifying diode. The capacitor stores electrical energy in an electric field. It is a passive electronic component with two terminals. The effect of a capacitor is known as capacitance. The two most common types of capacitors used in this project are ceramic and electrolytic capacitors. Ceramic capacitors are not polarised and can be used with their pins connected in any direction. Electrolytic capacitors are polarized and have positive and negative terminals which are connected to the positive and negative points.

The microcontroller is a small computer on a single metal-oxide semiconductor integrated circuit chip. PIC16F877A is used in the design of the robot, it is programmed to control the robot autonomously using sensors connected to it. This microchip has 8kb memory which is limited in size but sufficient for the work it is to do within the machine. The analogue to digital pins of the microchip are used to interface the analogous signals from the ultrasonic sensor and using the analogue to digital conversion built in and configured through the programming of the microchip, the machine could detect obstacles and make decisions to avoid them on time.

The microchip is not soldered on the mother board of the robot, but rather integrated circuit (IC) sockets are used to make contact with the motherboard. The pins of the integrated circuit (IC) connect into the IC socket making a firm electrical connection without the requirement of soldering. It enables an IC to connect in a circuit in a way it is not permanently attached to the circuit, it could be pulled out and replaced at ease. The IC socket is soldered onboard the motherboard of the circuit. There are 2 different IC socket sizes used, the 16 pin IC socket and the 40 pin IC socket. The 16 pin IC socket is used to house the radio frequency encoder and decoder chip while the 40 pin IC socket is used to house the 40 pin microcontroller.

For the microchip to function properly with accurate timing and execution of instructions, the 4MHz crystal oscillator is used to provide the frequency of operation. The crystal oscillator circuit uses mechanical resonance in an electronic circuit to produce vibrating electrical signals in a precise and accurate frequency. This frequency is used to keep track of time, so as to provide stable clock signal for the operation of the digital microchip system. This also provides a stabilize frequency for radio the transmitters and radio receivers. The PIC16F877A used external clock for the rate at which programs are executed. The 4MHz crystal oscillator makes it possible for the microprocessor of the microchip to execute instructions 4 million times a second (4MHz). The faster the oscillator, the higher or faster the rate instructions are processed and executed. The ultrasonic sensor also uses the crystal oscillator to generate the frequency it needs to drive the sensor.

The ceramic capacitors are used with the microcontroller oscillator, providing smooth square waves for the microchip timing. They aid the external clock (crystal oscillator) of the microcontroller to give clean frequency for proper timing and functioning of the microchip. The electrolytic capacitor is used to filter irregularity from the voltage regulator supplying power to the motherboard and other parts of the robot.

The mother board used is a dot matrix board on which every electrical component is connected to, excluding the Raspberry Pi module. The board is used to house electrical components of the system. Every component is embedded (placed) on the board and connections are made to or from it. Current flow does not enter the board unless the power button or switch is linked (powered on). The switches are used to close or open a circuit for electrical current to flow. Switches are connected from the battery terminals to the mother board components where current is directed appropriately. They also power the machine off when the robot work has been done. Buttons are used on the remote, to help provide a directional movement for the machine, this is embedded in the system since the remote was configured to be internal. When current flows into the mother board, resistors are used to reduce the current and voltage level. The resistors are used as voltage dividers, and current reduction. Proper calculation is done with the resistor loads to obtain the value of the resistors used for each component that requires the resistor. Resistor values are known based on their colour codes.

Formula for calculating resistance

$$V = I * R ; \quad (3.3)$$

Where V = Voltage

I = Current

R =Resistance

$$R = V / I \quad (3.4)$$

SI unit = Ohms Ω

$$Resistance = 1/Rt = 1/R1 + 1/R2 + \ldots .1/Rn \quad (3.5)$$

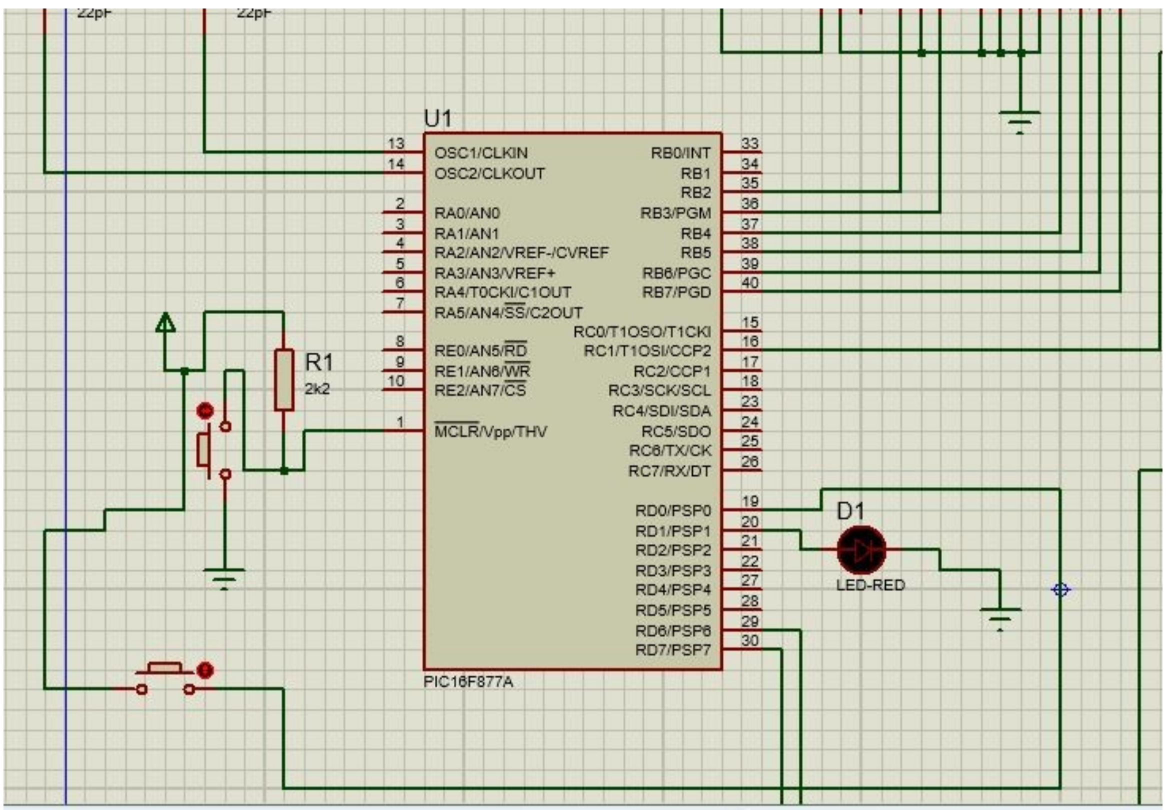


Fig 3.13 Schematic diagram of PIC16F877A microcontroller

The microchip was programmed to emit 7 bit binary signals to the transistors and sensors for amplification and actuation. When the microchip receives input from sensors, it makes decisions based on its program, if the sensors detect obstacle on its path, the microchip activates transistors connected to its terminals. A transistor is a semiconductor device used to amplify or switch electronic signals and electrical power. It is composed of semiconductor material usually with at least three terminals for connection to an external circuit. A voltage or current applied to one pair of the transistor's terminals usually the gate or base controls the current through another pair of terminals. Usually the controlled (output) power can be higher than the controlling (input) power. The IRFZ44 MOSFET transistors are used in this robot. This transistors switch the relays connected to it to make contact or to disconnect from a point. The relay is an electrically operated switch. It consists of a set of input terminals for a single or multiple control signals, and a set of operating contact terminals. Relays drive the motors of the robot. The switching of the relays make it possible for the terminals of the motors to be in either reverse or forward connection mode enabling the machine move forward, backwards or sideways. The MOSFET transistors accept a base voltage of 5 Volts and switch voltage of up to 60 Volts.

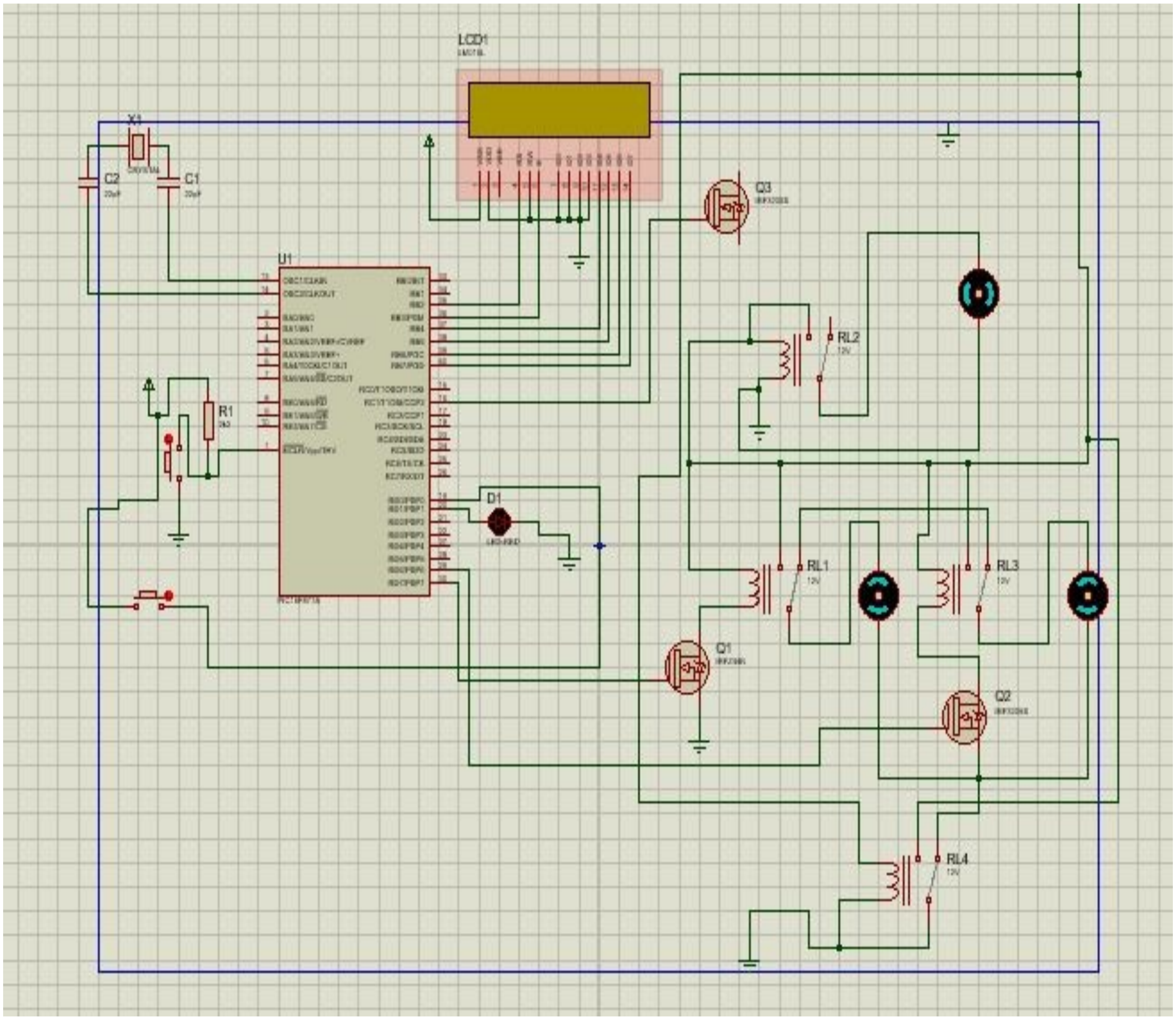


Fig 3.14 The drive circuit diagram of the robot

3.2.4 Programming computer vision and autonomous robot Navigation (The computer subsystem)

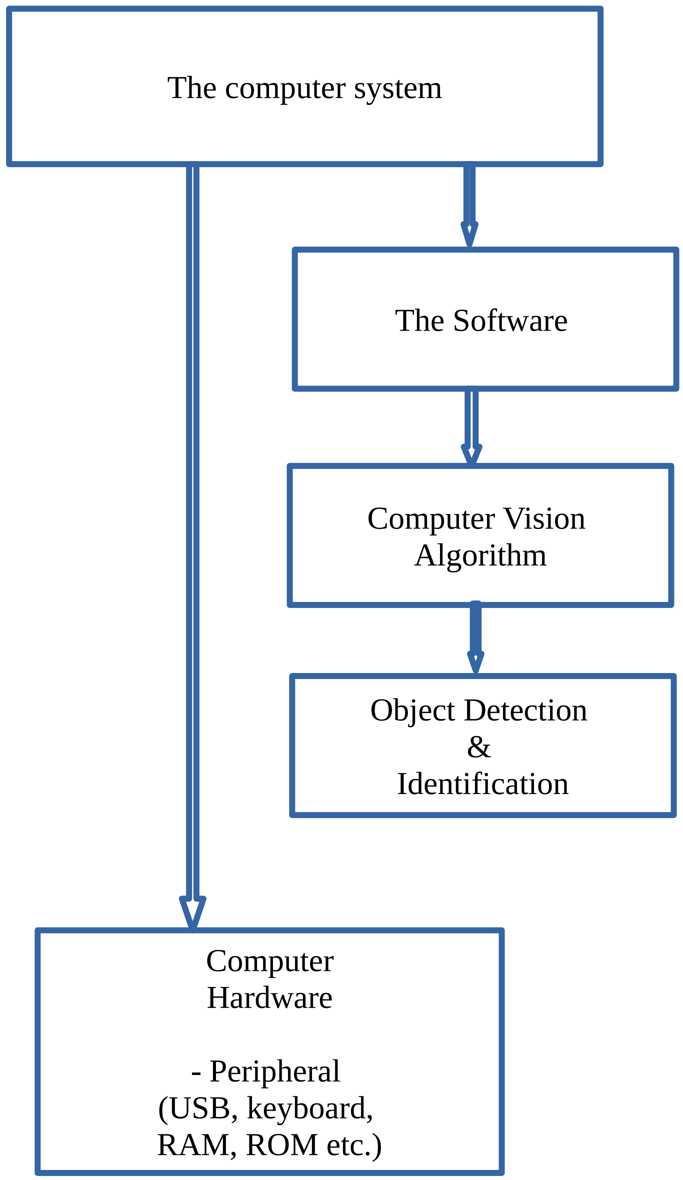


Fig 3.15 Block diagram of Computer subsystem

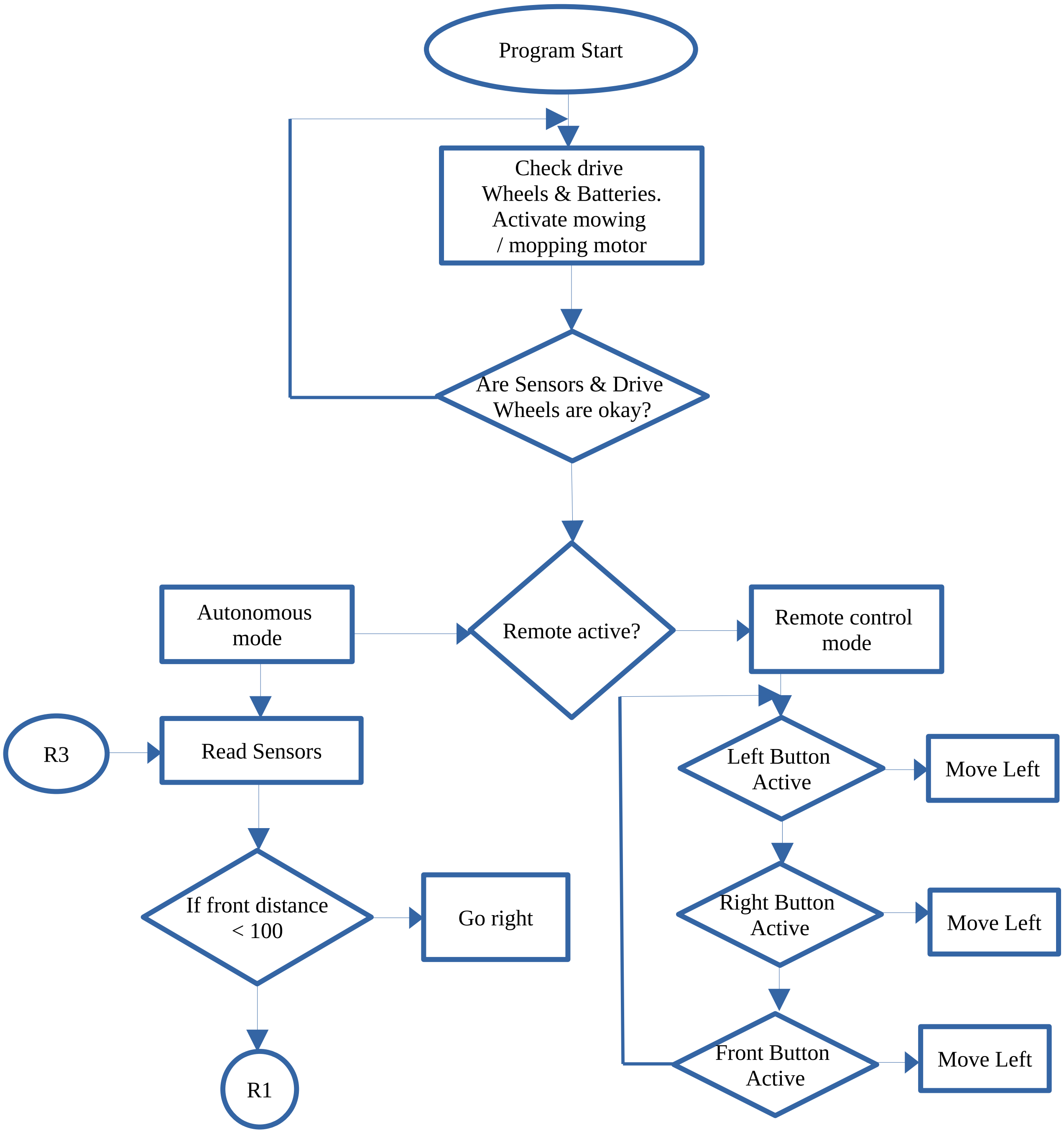
The Computer subsystem comprises of the computer hardware components which can be attached to and can be removed from the system. This section also involve the software which drive the system, the computer algorithms and programs enabling the system function, object detection and avoidance programs.

Table 3.12 On board Raspberry pi 4B specifications

Raspberry PI 4B	2GB RAM
USB ports	4
HDMI port	2
GPIO	40 pins
Camera slots	1
Micro HDMI	1
HDMI Cable	1
Memory	SanDisk SD Card
Size	32GB

(Raspberry Pi 2022)

3.2.4.1 Program Flow Chat



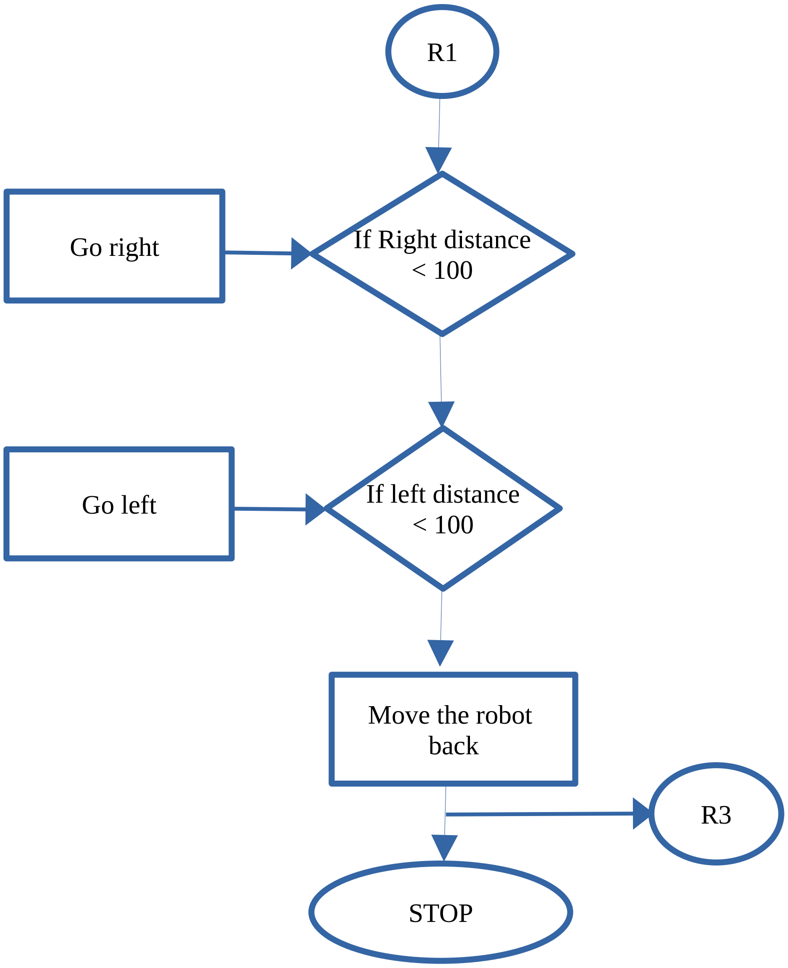


Fig 3.16 Program flow chat for autonomous navigation and remote control of the robot

3.2.4.2 Software Algorithm for robot navigation

1. *Initialise IC ports*
2. *Assign zeros to ports to clear memory*
3. *Start program execution*
4. *Deactivate drive motors*
5. *wait for 100 milliseconds*
6. *declare program variables*
7. *check drive wheels and activate actuators*
8. *check remote*
9. *if active go to remote control mode*

```
10.	else go to autonomous mode
11.
12.	go to subprogram again
13.
14.	remote control mode
15.	if front button is active
16.	switch on right and left actuators and move front
17.	if right button is active
18.	switch off right actuator
19.	switch on left actuator
20.	if left button is active
21.	switch off left actuator
22.	switch on right actuator
23.	pause motion actuators
24.	go to remote control model
25.
26.	autonomous mode:
27.	send signals to front sensor
28.	read front sensor feedback
29.
30.	send signals to right sensor
31.	read right sensor feedback
32.
33.	send signals to left sensor
34.	read left sensor feedback
35.
36.	if remote is active, go to remote control mode
37.	else autonomous mode
38.
39.	if front distance greater than 100 then move front
40.	if right space is greater than 100 move right
41.	if left space is greater than 100 move left
42.
43.	if front space is less than 100,
44.	check right space,
45.	if right space is less than 100,
46.	check left space,
47.	if left space is greater than 100, move left
48.	if left space is less than 100, move back
49.	else move right
50.	else move front
51.	Go Check remote line No 8
```

Program description, program can be found in appendix Robot navigation program to detect and avoid obstacles.

Software's are used in the development of this project, one of it is the Proteus Design Suite. This is a software developed by Labcenter Electronics Ltd. It is a propriety software tool suite used primarily for electronic design automation. The software is primarily used to for the electronic design and simulation of the robot electronic components and workability of the micro programs written for the microchip, it also provides schematics and electronic prints for manufacturing printed circuit boards, it could serve for different electronic design and simulation purposes, it has can give an in circuit debugging capability. During simulation software LCD's were simulated, movement of rotors were also simulated. But the transformer operation and radio transmission could not be simulated.

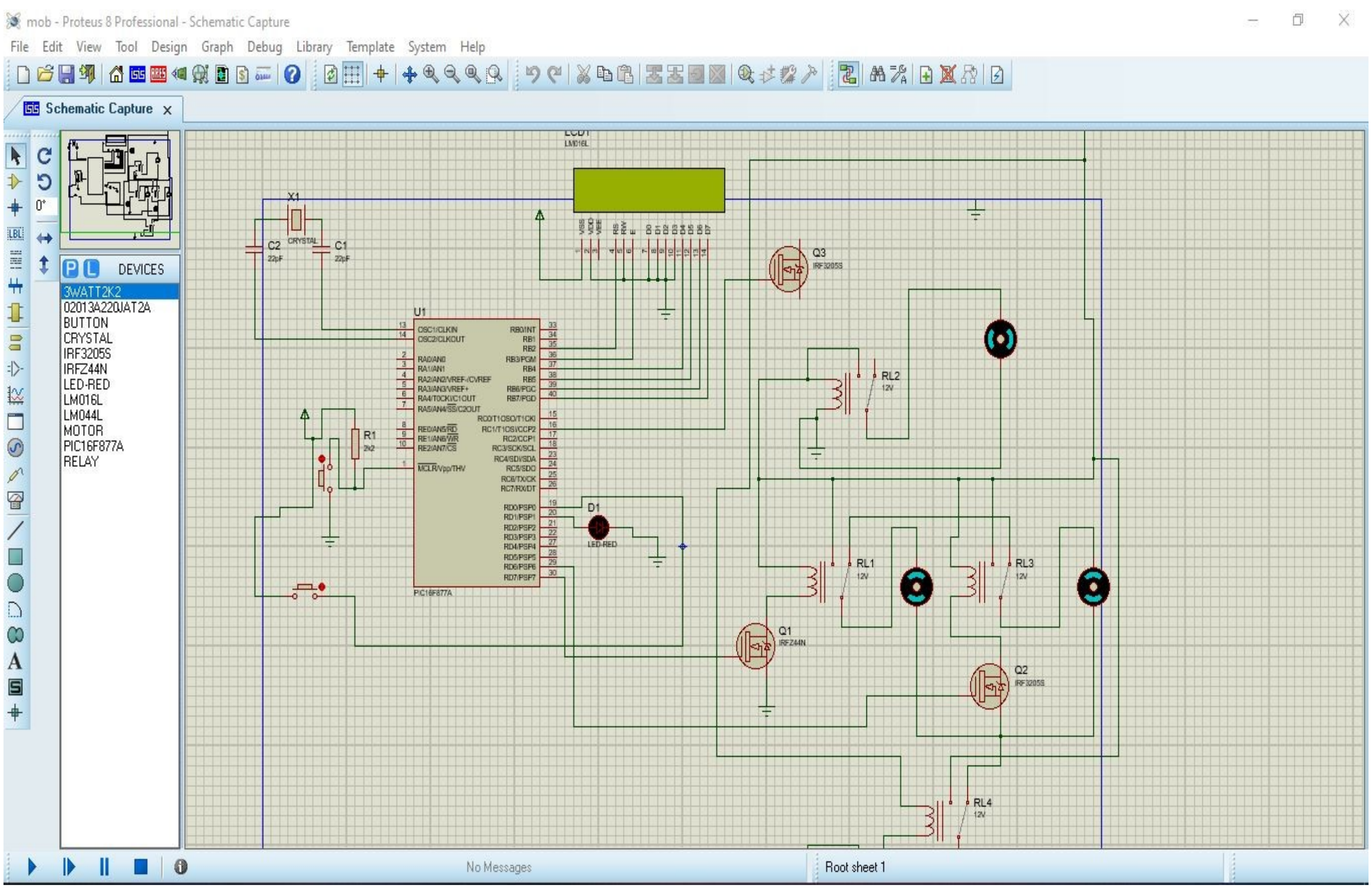


Fig 3.17 The Proteus 8 Design suite environment

MicroCode Studio is the software which was used for writing some of the programs which were listed in the material. The microcode studio provides an enabling environment for programming micro codes for microcontrollers. It was used to develop, debug and compile the programs stated above. This software generates the hexadecimal (Hex) file of the program which is compiled after been written and debugged. This Hex file is then copied into the microcontroller using the Top3000 universal programmer.

After programming and debugging, the program is compiled, but it does not remain in the computer where it is programmed. A Top3000 Universal programmer is used to copy the compiled program codes into the micro-controller (microchip) to be used for the project. TOP3000 universal programmer is designed to accommodate chips of different sizes, it could program almost all known microchips. It is easy to use and has no maintenance cost. The Top3000 universal programmer is equipped with an installer software which is properly installed into the computer to be used for copying the compiled codes to the microchip.

3.2.4.3 The Robot Camera and surveillance program

This program is written entirely with the python programming language and perfectly executed using python3. The program control the machine's camera making it possible for the operator to see obstacles which the machine sees in real time and try to avoid them when the machine is remotely controlled.

The program imports the open computer vision denoted as "cv2" and the numpy binary image manipulator, then using a variable named cap the system accesses the camera connected to it through the VideoCapture(0) function, this function with the "0" denoted accesses the internal camera of the computer, alternative camera can be added as external and the index number "0" be changed to either "1" or "2" depending on the camera index of the external camera connected to it. The cap.set() function using index 3 and 4 are used to set the width and height of the window frame. Fourcc(*xvid) is a video encryption used to save a video format. Using the videowriter_fourcc() function the camera can be accessed and the captured sequential images are saved as a video with the cv2.videoWriter() function assigned to the “output” variable. These functions deployed in this program have appropriate input which must be considered. A “while” loop is called upon to continuously check the state of the camera, and if the camera is open, recording and continuous execution of the codes within the loop is carried out. Within the loop, the output of the camera capture is displayed, the frame is flipped with the flip() function, the output variable is used to write the video to a file and the program awaits exit when the letter “q” is pressed. As soon as the letter “q” is pressed, the loop ends with a “break” statement leading to the release of the cap and output variables, and the closing and releasing of the camera and other video monitoring frame.

Robot camera surveillance algorithm

1. *import computer vision algorithm*
2. *import libraries*
3. *capture video feed from a connected*
4. *set camera height and width*
5. *assign video encryption*
6. *output camera display*
7. *loop through the camera system*
8. *capture and display camera*
9. *wait for q button to quit*
10. *if no quit instruction, loop*
11. *stop camera*
12. *kill frames*

Detailed program can be found in the Appendices

3.2.4.4 Robot Control through a remote computer

This is the robot control software through the IP address that is, the remote computer. When the onboard computer is connected online, a remote computer also connected online can be used to control the robot through the above program.

For this to work, a Linux based system is embedded into the machine, this Linux based system is the raspberry pi 4B module with 2Gb Random Access Memory (RAM) and 32Gb Read Only Memory. This system runs the Raspberry pi operating system and some other software packages. The Virtual Network computing server was installed on the system using the synaptic package manager and is launched immediately on system power on.

The raspberry pi 4B general purpose Input output pins (GPIO) are connected to the transmission remote system for the robot which can always be activated when in use. These GPIO pins are controlled through the terminal of the computer which the user controls remotely. The GPIO pins are 40 in number, and about 34 of the pins are input and output. four of these input output pins are connected serially to the transmission system.

When the terminal is opened and the program above loaded into the terminal, the program instructs the user to select the key for movement. For the system to function optimally, the transmitter must be switched on through the second switch on the machine. When the switch is powered, current flows to the transmitter letting the microcontroller know the machine is in remote mood, the microcontroller in turn switches to remote control mood giving full control to the operator of the machine. This allows the operator control the machine’s movement in any direction desired. When the code specified above is loaded into the terminal, the user selects directional movement for the robot by selecting the any of the keys and pressing enter after selecting “S, L, R, SS”

****

*   Robot control algorithm using IP address through a mobile phone or remote computer   *

****

```
Import general purpose input output drivers
import delay in robotic control
Display “Program to control robot remotely using python codes"
assign pin 16 to right drive actuator machine right
assign pin 20 to left drive actuator
assign pin 2 to stop machine
stop machine
switch on right actuator
switch on left actuator
Loop through the program
stop machine
switch on right actuator
switch on left actuator
switch on left actuator
switch on right actuator
pause machine for 5 seconds
switch off left actuator
pause for 2 seconds
switch on left actuator
pause for 2 seconds
switch off left actuator
pause for 2 seconds
switch on left actuator
pause for 2 seconds
pause for 5 seconds
switch off right actuator
pause for 2 seconds
switch on right actuator
pause for 2 seconds
switch off right actuator
```

pause for 2 seconds
switch on right actuator
pause for 2 seconds

if remote is off witch to autonomous control

End

3.2.4.5 System Logic

The system logic is carried out through the digital microcontroller stated in section 3.2.3. the PIC 16F877A microcontroller.

Table 3.13 System Autonomous Navigation

Sensor State	FRONT	LEFT	RIGHT	BACK
Front sensor > 100cm	True	False	False	False
Front sensor < 100cm Right sensor > 100cm	False	False	True	False
Front sensor < 100cm Right sensor < 100cm Left sensor > 100cm	False	True	False	False
Front sensor < 100cm Right sensor < 100cm Left sensor < 100cm	False	False	False	True

Table 3.14 Actuator Logic in Autonomous Navigation

Sensor State	LEFT	RIGHT	State of Machine
Front sensor > 100cm	True	True	Move Front
Front sensor < 100cm Right sensor > 100cm	True	False	Move Right
Front sensor < 100cm Right sensor < 100cm	False	True	Move Left

Left sensor > 100cm			
Front sensor < 100cm Right sensor < 100cm Left sensor < 100cm	True (INVERT)	True (INVERT)	Move Back

Table 3.15 Actuator Truth Table for Autonomous Navigation (USING OR)

Sensor State	LA	RA	FM	RM	LM	BM
Front sensor > 100cm	1	1	1	0	0	0
Front sensor < 100cm Right sensor > 100cm	1	0	0	1	0	0
Front sensor < 100cm Right sensor < 100cm Left sensor > 100cm	0	1	0	0	1	0
Front sensor < 100cm Right sensor < 100cm Left sensor < 100cm	1	1	0	0	0	- 1

Where

LA = Left Actuator   RM = Right Movement

RA = Right Actuator   LM = Left Movement

FM = Front Movement   BM = Back Movement

0 = False

1 = True

Table 3.16 System Remote Control Mode

Sensor State	FRONT	LEFT	RIGHT	BACK
Front Button	True	False	False	False
Right Button	False	False	True	False
Left Button	False	True	False	False
Stop Button * 1	False	False	False	False
Stop Button * 2	False	False	False	True

Table 3.7 Actuator Logic in Remote control mode

Sensor State	LEFT	RIGHT	State of Machine
Front Button	True	True	Move Front
Right Button	True	False	Move Right
Left Button	False	True	Move Left
Stop Button * 1	False	False	Stop
Stop Button * 2	True (INVERT)	True (INVERT)	Move Back

3.2.4.6 Camera and Computer Vision using OpenCV:

Computer vision tasks include methods for acquiring, processing, analysing, and understanding digital images, and extraction of high-dimensional data from the real world in order to produce numerical or information in the form of decisions. Computer vision can also be said to be the transformation of data from a still or video camera into either a decision or a new representation. These transformations are done to achieve a particular goal. The input data may include information from a camera, or laser.

Open Computer vision OpenCV is an open source computer vision library used to implement the camera vision. The library is written in C and C++ and runs under Linux and other operating systems. In this project, open computer vision was deployed in the Linux based operating system running on the Raspberry Pi computer used. Computer vision is used here to capture the environment using the camera connected to it. The machine is giving the ability to capture images when in security mode and when in operation. The images captured in security mode can be transmitted over over the internet for more advanced actions to be taken by the user as he or she sees the footage in almost real time.

3.2.4.7 Stages of Object detection and Object Identification used

Pre-Processing: To reduce the variability in the objects, the images captured by the robot camera was processed before they are fed into the computer network. All positive examples of the objects captured are obtained by cropping images that are identified by the system (humans, cat, dog). All the cropped images are then corrected for lighting through standard algorithms. In Machine Learning, data pre-processing and cleaning was a crucial step for effectiveness. Some samples of data preprocessing include but not limited.

Image pre-processing is the operation on images at the lowest level, that is, pixel manipulation or abstraction. The aim of pre-processing was to improve the image data that suppresses undesired distortions or enhances some image features relevant for further processing and analysis task.

There are 4 different types of Image Pre-Processing techniques used in this design and they are listed below:

1. Pixel brightness transformations / Brightness corrections
2. Geometric Transformations
3. Image Filtering and Segmentation.
4. Fourier transform and Image restoration

3.2.4.8 Pixel brightness transformations (PBT)

Brightness transformations was used to modify pixel brightness and the transformation depends on the properties of a pixel itself. In PBT, output pixel's value depends only on the corresponding input pixel value. Examples of such operators include brightness and contrast adjustments as well as colour correction and transformations. Contrast enhancement is an important area in image processing for both human, computer vision and the robot itself. It is widely used in robotics and I used PBT to enhance the quality of images captured in the design of the robot. There are two types of Brightness transformations these are Brightness corrections and Gray scale transformation.

3.2.4.9 The most common Pixel brightness transform operations:

i. **Gamma Correction:** Gamma correction is a non-linear adjustment to individual pixel values. This involve linear operations on individual pixels, such as scalar multiplication and addition/subtraction, gamma correction carries out a non-linear operation on the source image pixels, and can cause saturation of the image being altered.

ii. **Histogram equalization:** Histogram equalization is a well-known contrast enhancement technique due to its performance on almost all types of image. Histogram equalization provides a sophisticated method for modifying the dynamic range and contrast of an image. Unlike contrast stretching, histogram modelling operators may employ non-linear and non-monotonic transfer functions to map between pixel intensity values in the input and output images.

iii. **Sigmoid stretching:** Sigmoid function is a continuous non linear activation function. By adjusting the contrast factor and threshold value of the images and real time feed of the camera, it is possible to adjust the amount of lightening and darkening to control the overall contrast enhancement.

Geometric Transformations: With geometric transformation, positions of pixels in an image are modified but the colours are unchanged. Geometric transforms permit the elimination of geometric distortion that occurs when an image is captured. The normal Geometric transformation operations are rotation, scaling and distortion (or undistorted) of images.

Transformations carried out on captured images used for machine learning:

1. Scaling: Scaling is all about resizing of the image
2. Translation: Translation is the shifting of object’s location
3. Rotation: Just rotating an object with theta degrees
4. Shearing: Shifting the pixels horizontally
5. Affine Transformation: Instead of defining the scale factors, the shearing factors and the rotation angle, it is common to merge these three transformation into one matrix.
6. Perspective Transformation: Change the perspective of a given image or video for getting better insights about the required information.

Plate 3.1 Developed Robotic System

Table 3.18   Cost Implications of the study

Materials	**Specification**	**Quantity**	**Unit Price (N)**	**Cost (N)**
Raspberry Pi 4 B	Pi 4B	1	30,000	30,000
Actuators	Wiper Engine	3	17,000	41,000
Solar Panel		1	10,000	15,000
Relays	12v DC Relay	3	300	2,000
Ultrasonic Sensors	HC-HRO4	3	1,900	7,000
RF Transmitter and Receiver	XD-FST XD-RF-5V	1 1	1,500 1,500	3,000
HT12 Encoder and decoder chip	HT12D HT12E	2	500	3,000
MicroSD card	32 GB SanDisk	1	5,000	6,000
Mopping Brushes and Blade		2	2,000	4,000
Iron Container and Welding	3mm Iron	1	10,000	12,000
Tires		4	1,000	4,000
MOSFET	IRFZ44	3	200	700
Cables and switches		2 sets	500	1,000
Batteries	Panasonic	3	4,500	15,000
PVC Materials and gum			4,000	4,000
Microchip	PIC16F877A	1	3,000	3,000
Diodes	1N4007	7	10	70
Capacitors	2v100uF	2	30	60
Transformers	12-0-12 500mA	1	1,000	1,000
Soldering Lead		1	3,500	3,500
12 V regulator	7812	1	200	200
5 V regulator	7805	1	200	200
Transportation			10,000	10,000
TOTAL				165,730

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 The Mechanical System

After the machine frame has been designed and fabricated, and all welding work done. The motors and wheels were attached and fastened to the body frame which had been built. The electrical section of the robot which powers up every other part of the machine was assembled into the frame and sensors were held with either screws or hot gum or glue as the case may be. After the different components were assembled, the drive actuators were tested and functionality was confirmed, the mowing / mopping actuator was attached.

Motion actuators make 15 revolutions per minute when fully charged

RPM	=	60 +(-) 15
Turning angle	=	90 degrees
Turning distance	=	70 cm

For this to be actualised in autonomous mode, the microcontroller sends a high signal for 5 seconds to the appropriate actuator which enables the machine to make a turn.

These figures were based on the machine's movement on a tiled surface and defined environment. In an undefined area such as the field, the remote control was used to navigate the environment.

The drive motors are controlled by the program written and copied into the chips. This chips control relays which drive the motors, brushes are coupled to the motors when the need for mopping arises, and the brushes are removed to give room for the blades to be attached when it is to be used for mowing. A high torque motor commonly used in car and tricycle wipers is used to drive the movement of the robot. During operation, the left drive motor operates with it's terminals connected in parallel with the batteries while the right motor's terminals are connected with reverse polarity, and it enables the motors drive the wheels moving the machine forward, and also backwards. A round drive rod of 12cm in length and 2cm in width was welded to the motors to create room for the robot tires to be fastened to the motors so as to enable rotation of the wheels and movement of the robot. Rubber tires made of polymeric substances (rubber) were used in the thesis. The back wheels are different in dimension and design from the front wheel. Large back wheels were selected to provide support for the weight and to provide traction and force needed to move through a slippery area and a rough environment. Slim front wheels are used for easy turn around of the robot, it has a rubber surface to enhance grip on slippery and rough surfaces.

The brush and blade are the interchangeable components of the robot, they are made in a way that they can be detached from the electric motor driving them. The blade is a metal bar of 1mm thickness and sharpened to cut grasses at ease, while the brush was constructed from a polymeric thread like material and held together with strong gum. To mop, the brush is attached to the motor, and the dryer attached to the rare of the robot. This gives the robot the capacity to brush the floor and as well dry it with the help of the mop attached behind the machine. As the actuator rotates, the brush attached to it rotates, at 200 rpm.

To mow, any remaining liquid in the machine is emptied by allowing it flow out on its own. Empty the water reduces weight for use in an outdoor environment. When this has been done, the user changes the brushes with the blades that will be used for mowing. These blades also rotate at the rotation speed of the drive motor it is attached that is 2000 RPM.

Within the robot, Polyvinyl (PVC) is used to store water and channel the mopping liquid stored in the container through the pipes to the outlet ports. As the robot moves the mopping liquid is sprinkled on the floor while the brush rotates. These chemicals are poured into the internal plastic container (3 litters) through a piping system.

4.1.1 The mopping subsystem: The piping system was done with polyvinyl chloride materials to ensure no water leaks. Aluminum foil was also used to seal the liquid container to provide better protection and avoid any form of liquid leaks to protect the electrical materials from damage.

As the machine moves along a path, it sprayed some quantity of the mopping liquid on the floor along its path of motion, this lubricated the floor and provided some antiseptics against germs and insects, it's spinning underneath brush attached to the motor protruding from the bottom of the machine rotates at a high speed of absolutely 2400RPM, this rotational movement drives the brush attached to it to brush the sprayed floor around 2400 times a minute, providing a good scrubbing of the floor and also at the same time disinfecting the region. As the robot moved forward, the attached drying mop behind the robot dried up the liquid leaving the floor with little or no liquid after its operation. Once mopping was done, the robot remote system should be activated to drive the robot to safe place where its mopping and drying brushes can be removed and the remaining liquid contents be emptied to avoid further spray of liquid on the floor.

4.1.2 The mowing subsystem: This system is similar to the mopping system. To mow, the mopping brushes are removed and the mowing blade attached to the motor beneath the robot. This blade is handled with care and attached fastened with its bolts to avoid disengaging during operation. The robot remote control is activated, either with direct remote control or through the internet using the onboard computer and the VNC server installed on the computer. When the remote system is active, the robot can be remotely controlled into the environment it is to work and controlled while it does its work of mowing. During mowing, the blades rotate at a high speed of 2400 rotations per minute, this speed makes it possible to mow smoothly grasses be not more than 20cm in height. While mowing, the machine vibrates, a mechanism was deployed to absorb the vibrating blades and keep the motor and machine steady.

4.1.3 The cooling subsystem: During operation, the robot is expected to heat up especially when working under the sun. This requires cooling to avoid damaging the electronic components. Because of this, a cooling system was installed to avoid over heating, this system takes away heat from the machine and is activated as the machine is switched on. A direct current fan of 12 Volts 0.3 Amps is used to cool system when working, the fan has two terminals, the negative and positive terminals. The positive terminal is connected to the positive power supply which is controlled by the machine on and off switch, while the negative cable of the fan is connected to the negative terminal of the battery, when the machine is switched on, the fan is automatically switched on because it is the same switch that controls both the power up of the machine and the fan.

4.2 The electrical and communication system

The Solar Power cells make the robot self sufficient in terms of energy generation and usage. It makes it possible for the robot to function even in areas of limited power supply, sunlight is all that is needed to power the device and recharge the battery. The panel generates 18 V – 22 V DC 20watts which was enough for recharging and powering the machine. IN4007 diodes are used for rectification and allow current flow in one direction, from the solar panel to the battery system, while it prevents power flow back to the panels, It is also used to direct current flow from the microchip to the MOSFET controlling the relay. With this it protects the microchip and to avoid surge from current in the relays. Relays are known to switch between higher currents and voltages. In this situation, the diode is used to prevent high current from flowing into the MOSFET and the microcontroller therefore protecting the system to prevent damage. The solar system charges the batteries while in use, and provides extra power to keep the machine running for a longer period of time, it also charges the batteries when in an idle state.

The electrical connections were made and the solar panel produces 15 watts at 1.8 amp / hour, this energy charged the batteries and provided enough power to supplement when the machine is operational. This energy from the panel sufficiently charges the batteries in 24 hours. In a poor lighting condition, an alternative alternating power source was used to charge the batteries and the machine charged within 48 hours when the batteries are completely down.

The radio communication channel developed used 433Mhz to operate the transmitter and receiver within the machine. The system used its ultrasonic sensors to check its proximity with objects and obstacles in its path, this function works with an accuracy of 99% when objects are directly in front or by the side and about 75% when objects are 45 degrees or 135 degrees to the sensors. The computer is controlled over the internet at a specified IP address of (170.20.10.3) as at when tested. A new IP address can be obtained and used to connect to other devices.

4.3 Computer System and computer vision

With the raspberry pi 4B which had the raspberran operating system, and other software which were installed for computer vision and camera accessibility. The remote control navigation enables the machine to be controlled remotely. Videos and image feeds were captured remotely using an Apple iPhone 6 which runs a VNC viewer, and also using a HP laptop running a VNC viewer on Ubuntu operating system. This is evidence that the machine could be controlled remotely from any computer device or mobile phone running a VNC viewer with an internet connection.

The program is developed for the robot autonomous navigation. This program makes it possible for the robot to use it’s sensors (ultrasonic sensors) to detect obstacles and pathways on its path. When the ultrasonic sensor receives a trigger signal from the microcontroller, the transducer sends out radio wave at 433MHz for the specified time of 50 milliseconds which is stated in line 117, 125, 133 of the program. The micro-controller emits the trigger signal for the front sensor with the instruction PULSOUT PORTD.0 50 (pulse out to port D pin 0 of the microchip for 50 milliseconds), to PORTD pin 0 of the micro-controller to the trigger pin of the front sensor, the right sensor gets its own trigger signal using the same instruction through PORTC pin 5 of the microcontroller, the left sensor also gets a trigger signal through the PORTC pin 7 of the microcontroller.

When this signal is transmitted, an echo is bounced back from the surface of any object or obstacle on the path to the transducer. This echo signal is received at each individual sensor of the robot. The front sensor receives its echo signal and relays it through to the microcontroller. The microcontroller reads this signal through the instruction PULSEIN PORTD.1, 1, FRONT (pulse in at port D pin 1, wait for 1 second and store the value in a variable named FRONT), this is stated in line 118 of the program above. The same process repeats for the left sensor which reads its own values through line 134 of the program above and the right sensor is also read through line 126.

Line 141 -156 of code is the robot movement decision making section. It analyses firstly the state of the machine as stated in line 144. This line of code (144) checks the system and the transmitter to ensure the system is not in remote control mood, if port B pin 0 of the microcontroller has a high signal on it, the system automatically enters a remote control mood allowing the operator have full control of the machine. If the signal is low, the code is ignored and next line of code is executed.

In autonomous mood, the machine uses the codes specified in line 146 to line 152 to check the distance of objects in centimetres from the robot. If the front sensor reads a distance and it is greater than 100 cm execution is jumped to code line 172 of Robot Navigation program.

Line 169 specifies the sub program GOFRONT: line 173, 174, 175 switches PORTC.2, PORTC.1 and PORTC.0 high respectively activating the two drive wheels of the robot and the mopping and mowing motor. This program take no time to execute (that is, it executes asynchronously). The last statement of the subprogram GOTO AGAIN states the program execution should be sent back to the line 112 which again loops through the sensors and the entire process is executed again in an infinite loop.

If the front sensor reads a value less than 100 meaning an obstacle is within 100 centimetres, the program line 173 is false, then the next line of code is assessed, if line 174 is true, then the program control jumps to line 182.

In the GORIGHT sub program, the micro-controller is instructed to switch off the two drive actuators as stated in line 183 and line 184 using the commands LOW PORTC.2 and LOW PORTC.1. Line 185 compares the right and left sensor values, if there is more space in the left side of the machine, that is, the left value is higher than the right, the execution jumps to line 194 to the sub program GOLEFT as stated below. If line 147 of the program evaluates to false, the next line of code 148 is executed. Line 198 activates the left drive wheel while the right drive wheel remains off forcing the machine to make a turn to the right in 3000 milliseconds (3 seconds) as stated in line 187 of the instruction.

If the conditions of line 185 evaluates to true, the below subprogram (GOLEFT) executes in the same way the GORIGHT subprogram executed.

Line 150 executes the subprogram to go back when the front sensor, left sensor and right sensor read values less than 100cm. This means there is no space in the path of the robot, the machine tries to go backwards avoiding collision with any obstacle on its path.

4.3.1 Surveillance:

The robot monitors an environment using its onboard camera and computer while remotely being controlled from anywhere in the world through internet connection. This computer vision technology detects motion at 100 meters and more, and with high precision. The size of motion being detected can be adjusted within it’s program from things as small as rat movement to motion as large as that of human and cars. It is observed that the farther the distance from the object the lower the sensitivity of object being detected. Humans can be detected at about 0 to 100 meters but depreciates in sensitivity above 100 meters.

4.4 Testing the developed system

Tests were carried out on the drive mechanism, its mowing and mopping functionality, surveillance has also been tested and it has proven its efficiency.

Movement of the robot was first fixed because a mopping or mowing machine that could not move would not do the work it is designed to do. Fixing and getting the machine to move and avoid obstacles was the first problem solved. To get the machine moving and avoiding obstacles, the sensors need to work perfectly to detect the obstacles ahead. It was programmed to detect obstacles at 1 meter or 100cm to give room for calculation and turning or reverse movement in situations with limited space for a left or right turn. The machine could cover a distance of 14 meters in 20seconds making it fast enough to mop floors with accuracy and mow with ease.

4.4.1 Mopping

To mop, the blade used for mowing must be removed and the brush for mopping attached beneath the robot. This brush must be attached to make contact with the floor but not heavy contact to enable the brush spin perfectly. The brush is fastened to the motor that controls the rotation of the brush and blade (during mowing), while the cleaner is attached behind the machine enabling the machine drag it along. Then the liquid (usually water) mixed with a cleaning agent is poured into the machine before the machine is powered on. Using this robot to mop gives 85% efficiency in an environment with obstacles and about 95% in environments devoid of obstacles. The machine has great efficiency in detecting objects and making a decision ahead of time to avoid colliding with the obstacle while still mopping the floors.

4.4.2 Mowing

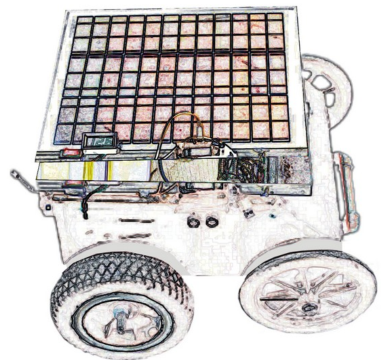


Plate 4.1 Robot mowing

Plate 4.2 System Sketch

To mow a lawn, the mopping brushes and cleaners are removed, the PVC emptied, and the blade is fastened to the motor beneath. The robot is then driven with its remote to the mowing site and controlled or allowed to mow if the environment is confined to prevent the robot from wondering off. It was discovered to mow autonomously using its ultrasonic sensors. Some limitations occurred when it encountered tall grasses, the machine saw the grasses as obstacles therefore avoiding them and choosing a different direction to mow. During autonomous mowing, it navigates itself without any human help, in some situations obstacles were intentionally placed in its path which it eventually did well by avoiding.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The testing ensured every part of the machine worked as it is supposed to. The initial mowing test was conducted at the Claretian University Nigeria football field, the final mowing test and mopping tests were conducted at the School of Engineering, Electrical Engineering department of Federal University of Technology Owerri, Imo State Nigeria. It's surveillance capability was also conducted at the Federal University of Technology. Mowing and mopping capability and navigation with object avoidance were also tested and results obtained in details.

Finally from the result obtained from the test the primary objectives of the system to develop drive mechanism for mopping, mowing and surveillance was actualised, the development of radio communication channel for robot navigation using Wi-Fi over the internet and ultrasonic sensor was achieved, the development of power for the electronic system was achieved, the programming was also achieved. Incorporation of the three major functionalities of mopping, mowing and surveillance into a single developed system was achieved. This work has also eliminated the need to design three different machines for three different purposes. Elimination of dangerous gasses into the air has been reduced to 0% contributing to a healthy and safe environment. This study has also proven that robots can be designed and can carry out specific high level and sophisticated tasks with common technology found within and around us.

5.2 Recommendation

1. This work is strongly recommended for a large well defined areas like hospitals, airports, and shopping malls. In a private or government restricted area, it is recommended to be used to survey the environment for security reasons.
2. The machine can be further programmed to pause it's mowing blade autonomously to avoid injury when someone comes close to it.
3. It can be further enhanced with more sensors to work more effectively in its autonomous navigation mode.
4. It can also be further programmed to enhance its capabilities and functionalities

5.3 Contribution to Knowledge

In this study, a robot was developed to mow, mop and survey an environment using raspberry pi 4 B technology, computer vision and radio communication technologies. This machine can be controlled remotely from kilometres away over the internet through the computer's IP address and a virtual network server. With a smart phone, or a computer connected remotely this robot can also be programmed and reprogrammed in real time giving it a high degree of flexibility and control.

This study has brought justice to mowing, mopping and surveillance as no robot with the specific features has been developed with the capacity and capability to carry out these tasks in real time and posses the features of real time programmability. This study can be life saving, it could be deployed in a life threatening environment to survey and give a real time feed back of the environment. This study also shows that emissions from machines can be reduced to zero by the use of renewable energy. The problem of safety and ease of use is also solved, it can be remotely controlled by anyone irrespective of the age and gender, or physical strength. It is cheap and affordable, it can be easily maintained as parts of it can be purchased from and within the society.

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```
*******************************************************************************
*                  Robot Camera and surveillance program                      *
*                                                                             *
*******************************************************************************

import cv2                          #import python3 open computer vision
import numpy as np                  #import python3 numpy

cap = cv2.VideoCapture(0)           #assign video capture to cap
cap.set(3, 320)                     #set camera display width to 320px
cap.set(4, 320)                     #set camera display height to 320px
fourcc = cv2.VideoWriter_fourcc(*"XVID")        #use xvid video encryption

output = cv2.VideoWriter("Video.mp4", fourcc, 20.0, (640, 480))    #set output properties

while(cap.isOpened()):              #loop to continue display and record
    net, frame = cap.read()         #read camera data

    if net == True:                 #if camera is connected and functioning
        frame = cv2.flip(frame, 0)  #set camera orientation to default 0

        cv2.imshow("Frame", frame)          #display camera frame on monitor
        output.write(frame)                 #write to memory what is captured
        if cv2.waitKey(1) & 0xFF == ord("q"):       #if q is pressed, quit / exit program
            break                   #exit loop


cap.release()                       #release camera
output.release()                    #release writing to disk
cv2.destroyAllWindows()             #close all programs
```

****
*   **_Program enabling the robot to detect objects_**   *
*   *
****

```
import cv2
import numpy as np

cap = cv2.VideoCapture(2)

net, frame1 = cap.read()
net, frame2 = cap.read()


def writeData():

   cv2.imwrite("new2.jpg", frame1)

   #outfile = open("movementCordinates.txt", "a")
   #outfile.write("Movement Detected\n")
   #outfile.close()



while cap.isOpened():

   diff = cv2.absdiff(frame1, frame2)
   gray = cv2.cvtColor(diff, cv2.COLOR_BGR2GRAY)
   blur = cv2.GaussianBlur(gray,(5,5), 0)

   _, thresh = cv2.threshold(blur, 20, 255, cv2.THRESH_BINARY)
   dilated = cv2.dilate(thresh, None, iterations=3)
   contours, _ = cv2.findContours(dilated, cv2.RETR_TREE, cv2.CHAIN_APPROX_SIMPLE)

   for contour in contours:
      (x,y, w, h) = cv2.boundingRect(contour)

      if(cv2.contourArea(contour) > 2000) & (cv2.contourArea(contour) < 5000):
         continue
      cv2.rectangle(frame1, (x,y), (x+w, y+h), (0, 255, 0), 2)
                  cv2.putText(frame1, "Status: {}".format("Movement Detected"), (10, 20),
cv2.FONT_HERSHEY_SIMPLEX,
      1, (0,0,255), 2)
      #writeData()
```

```
    cv2.drawContours(frame1, contours, -1, (0, 255, 0), 2)
    cv2.imwrite("new1.jpg", frame1)
    cv2.imshow("Feed", frame1)

    frame1 = frame2

    ret, frame2 = cap.read()

    if cv2.waitKey(40) == 27:
        break

cv2.destroyAllWindows()
cap.release()
```

****

Robot Navigation Program to detect and avoid obstacles

****

```
'**************************************************************************
'*  NAME          : ROBOT_CONTROL.BAS                          *
'*  AUTHOR        : [ERNEST ARINZE EHIRIM]                            *
'*  NOTICE        : COPYRIGHT (C) 2021 [ERNEST_EHIRIM]                 *
'*                : ALL RIGHTS RESERVED                               *
'*  DATE          : 6/20/2021                                       *
'*  VERSION       : 1.0                                             *
'*  NOTES         : MICROCHIP PROGRAM FOR THE DIGITAL MOPPING     *
‘*                  MOWING AND SURVEILLANCE                           *
'*                                                             *
'*********************************************************************
‘**********************************************************************
‘*INITIALIZE MICROCHIP PORTS, ASSIGN INPUT AND OUTPUT PORTS     *
 ‘*                 RESPECTIVELY                        *
‘**********************************************************************
TRISA = %11111111
TRISB = %00000001
TRISC = %01111000
TRISD = %00000000
TRISE = %00000
‘*******************************************************************
‘*                 CLEAR MEMORY                          *
‘*******************************************************************
PORTA = 0
PORTB = 0
PORTC = 0
PORTD = 0
PORTE = 0
‘******************************************************************
‘*    START PROGRAM AND INITIALIZE VARIABLES                *
‘******************************************************************
START1:
HIGH PORTC.0
pause 100
X VAR WORD
VAL VAR WORD
FRONT VAR WORD
RIGHT VAR WORD
LEFT VAR WORD
FRONT1 VAR WORD
RIGHT1 VAR WORD
LEFT1 VAR WORD
```

```
LCDOUT $FE, 1
PAUSE 100

LCDOUT $FE, $80, "ROBOT FOR MOWING"
LCDOUT $FE, $C0, "   & MOPPING"
PAUSE 500

LCDOUT $FE, 1
PAUSE 100

LCDOUT $FE, $80, "ENGR E.A. EHIRIM"
PAUSE 500

IF PORTB.0 = 1 THEN GOTO REMOTE1

GOTO AGAIN

GOTO START1

'LCDOUT $FE, 1
'PAUSE 100

'LCDOUT $FE, $80, "ENTERING AGAIN"
'PAUSE 1000

'GOSUB REMOTE
'GOTO AGAIN

‘*****************************************************************
‘*                    REMOTE MODE                                *
‘*****************************************************************


REMOTE1:

LOW PORTC.1
LOW PORTC.2
GOTO REMOTE

REMOTE:
PAUSE 50

LOW PORTC.0
PAUSE 50

PAUSE 100
PAUSE 10

GOTO REMOTE



‘*****************************************************************
‘*      LOOP THROUGH THE SENSOR DATA, MAKE CALCULATIONS          *
‘*      MAKE DECISIONS, AND NAVIGATE AVOIDING OBSTACLES          *
```

```
‘****************************************************************
AGAIN:
‘****************************************************************
‘*                FRONT SENSOR CONTROL                          *
‘****************************************************************
'FRONT SENSOR
PULSOUT PORTD.0, 50
PULSIN PORTD.1, 1, FRONT
FRONT1 = ((FRONT * 10) / 55)
‘****************************************************************
‘*                RIGHT SENSOR CONTROL                    *
‘****************************************************************
'RIGHT SENSOR
PULSOUT PORTC.5, 50
PULSIN PORTC.4, 1, RIGHT
RIGHT1 = ((RIGHT * 10) / 55)
‘****************************************************************
‘*                LEFT SENSOR CONTROL                     *
‘****************************************************************
'LEFT SENSOR
PULSOUT PORTC.7, 50
PULSIN PORTC.6, 1, LEFT
LEFT1 = ((LEFT * 10) / 55)
'LEFT1 = LEFT
LCDOUT $FE, 1
PAUSE 50
‘****************************************************************
‘*          ROBOT MOVEMENT DECISION MAKING                 *
‘****************************************************************
IF PORTB.0 = 1 THEN GOTO REMOTE1
IF FRONT1 > 100 THEN GOFRONT
IF RIGHT1 > 100 THEN GORIGHT
IF LEFT1 > 100 THEN GOLEFT
IF FRONT1 < 100 AND RIGHT1 < 100 AND LEFT1 < 100 THEN GOTO GOBACK
If PORTB.0 = 1 THEN GOTO REMOTE1
GOTO START1
‘****************************************************************
‘*                BACK MOVEMENT CONTROL                   *
‘****************************************************************
GOBACK:
'OFF ALL MOTORS
LOW PORTC.1
LOW PORTC.2
LOW PORTC.0
```

```
PAUSE 1000
GOTO AGAIN

‘******************************************************************
‘*                FRONT MOVEMENT CONTROL                    *
‘******************************************************************

GOFRONT:
HIGH PORTC.2 'RIGHT WHEEL TO GO LEFT
HIGH PORTC.1 'LEFT WHEEL TO GO RIGHT
HIGH PORTC.0 'BLADE
GOTO AGAIN

‘******************************************************************
‘*                RIGHT MOVEMENT CONTROL                    *
‘******************************************************************

GORIGHT:
LOW PORTC.2
LOW PORTC.1
IF LEFT1 > RIGHT1 THEN GOLEFT
HIGH PORTC.2
PAUSE 3000
GOTO AGAIN

‘******************************************************************
‘*                LEFT MOVEMENT CONTROL                     *
‘******************************************************************

GOLEFT:
LOW PORTC.1
LOW PORTC.2
IF RIGHT1 > LEFT1 THEN GORIGHT
HIGH PORTC.1
PAUSE 3000

‘******************************************************************
‘*                LOOP MOVEMENT                 *
‘******************************************************************

GOTO AGAIN

END

‘******************************************************************
‘*                END OF PROGRAM                *
‘******************************************************************
```

```
***************************************************************************************
*            Robot control using IP address through a mobile phone or remote computer          *
*                                                                                        *
***************************************************************************************

from gpiozero import LED          #input general purpose input output drivers
from time import sleep           #import delay in robotic control

print("Program to control robot remotely using python codes")              #
right = LED(16)             #assign pin 16 to right drive actuator machine right
left = LED(20)              #assign pin 20 to left drive actuator
back = LED(2)               #assign pin 2 to stop machine

back.on()                   #stop machine
right.on()                  #switch on right actuator
left.on()               #switch on left actuator

while True:

    back.on()               #stop machine
    right.on()              #switch on right actuator
    left.on()           #switch on left actuator

    left.on()           #switch on left actuator
    right.on()              #switch on right actuator

    sleep(5)            #pause machine for 5 seconds

    left.off()              #switch off left actuator
    sleep(2)            #pause for 2 seconds
    left.on()           #switch on left actuator
    sleep(2)            #pause for 2 seconds

    left.off()              #switch off left actuator
    sleep(2)            #pause for 2 seconds
    left.on()           #switch on left actuator
    sleep(2)            #pause for 2 seconds

    sleep(5)            #pause for 5 seconds

    right.off()             #switch off right actuator
    sleep(2)            #pause for 2 seconds
    right.on()              #switch on right actuator
    sleep(2)            #pause for 2 seconds

    right.off()             #switch off right actuator
    sleep(2)            #pause for 2 seconds
```

```
right.on()          #switch on right actuator
sleep(2)        #pause for 2 seconds
```