FACULTY OF ENGINEERING, TECHNOLOGY& BUILT ENVIRONMENT

GROUP PROJECT FINAL REPORT

EK408 Mechatronic System Design

Title: Remote Operated Herbicide Sprayer with Control Droplet Applicator for Palm Plantations

Instructors: Dr. Elango Natarajan

Student Name	ID
Jayanth Kumar	1001851644

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Regards,

Jayanth Kumar 1001851644

ABSTRACT

In this project work an engineering solution to the current human health is achieved which avoids human involvement while spraying toxic chemicals in the agricultural fields. This is achieved by the design and construction of an autonomous remote operated mobile robot for use in herbicide/pest control and disease prevention applications in commercial plantation fields. The automatic herbicide sprayer is designed for various applications. With the remote control we can send the sprayer to various parts of plantation where spraying by humans is not possible and is very fast and accurate than mankind. It can spray herbicide to the root of field and save the greenery from the attack of herbs, pests etc. In today's world Agriculture has become one of the major occupations. Farmers use chemicals to control pests and the growth of unwanted herbs. Tradition farmers spray herbicides or pesticides using Lever Operated Knapsack Sprayer. By using Knapsack sprayer, the amount of chemicals sprayed is not controlled, and manual spraying results in affecting the farmers health due to direct contact with chemical. By using manual sprayer, the farmer might spray too much chemicals resulting in crop damage and reduces the fertility of the soil. In order to avoid the following issues, we have come up with Automated Spraying Robot which can be operated remotely. By using this robot, he/she can avoid direct contact with the chemicals and can reduce workload to save up time. This robot automatically mixes the chemicals and water and uses Controlled Droplet Applicator to spray the herbicide into droplets of relevant size and mass using Nozzle. This robot is controlled using Arduino Mega which can be operated from hand phone using application we built and can be operated up to a range of 50 meters. The speed of the robot and spraying mechanism can also be controlled from touch of your hand.

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CHAPTER 1

1.1 INTRODUCTION

In today's environment, pesticides and herbicides are used to eliminate undesired plants, insects, and other organisms that are potentially hazardous to plants. The herbicides or insecticides must be sprayed manually by farmers which damages their health [1]. The cultivation of mountainous and palm plantation requires a high number of working hours (higher than 1500 h/ha/year), with human labor being increasingly rare and costly [1]. Therefore, palm growers are considering innovative mechanization solutions to reduce operating costs, execute timely cultural practices, and increase flexibility within their operations. Spraying is a critical operation for these palm plantations since they account for about 20–30% of the total annual work time of the plantation. The main bottlenecks for spraying these plantations are the lateral and transversal slope, terrain with a stony surface, narrow row sizes (90–150 cm), bards' curvature, and canopy heterogeneity [2]. Currently Knapsack sprayers or a small tractor-based system equipped with air blast sprayer [4]. These types of sprayers are sprayed manually in presence of human in the plantation site. By using manual sprayers, the amount of herbicide or pesticide sprayed is not controlled by which the crop is damaged [6]. During typical working hours, the ideal temperature and humidity levels at plantation may be rather high (up to 38°C), making it exceedingly hot and uncomfortable for someone wearing heavy protection equipment [7]. This puts the worker at danger of heat stroke and other health problems that come with such situations. Inhalation of pesticides used at planation site can be lethal or cause lasting harm to lung tissue in some situations. Even a little quantity of exposure to a variety of chemicals over a lengthy period can be hazardous to a worker's health. Protective clothes and equipment must be used due to the dangers of such exposure [5]. Protective gear, on the other hand, reduces but does not eliminate the risk of exposure, according to study. In this kind of situation 'Remotely operated Robot Sprayer' comes in handy. The farmer can operate this sprayer from a comfortable place without any exposure to Sun and chemicals. The robot built by us comes with 3 tanks, a serial manipulator for spraying, a camera to spray correctly at required spot and a long-lasting battery [4].

Figure 1 Oil palm plantation view

1.2 Problem Statement

Farmers suffer large financial losses because of usage of incorrect irrigation mechanisms, insect pests and attack of plant diseases, usage of uncalculated amount of pesticides and herbicides, and wrong prediction of weather. Using wireless robot reduces labour costs while also allowing for precise tracking of changes that occur in real time at the field. Farmers must take numerous precautions when spraying herbicides, including wearing proper clothing, gloves, and masks, among others. In such situations, the use of robotics is a very imminent technological solution that increases productivity and efficiency. On the earth 42% of population is dependent on an occupation of agriculture, they must do a lot of work and more load on them. Spraying herbicides is one of the jobs that is risky and challenging because the chemicals used in herbicide liquids are hazardous [18]. It may cause breathing difficulties as well as other physical issues. As a result, we created an agricultural robot that assists farmers in spraying herbicide liquid while reducing workload.

1.3 Objectives

- To stop manual spraying on the real plantation with pesticides or herbicides. This will reduce the plant's excessive use of pesticide.
- To build a spraying robot in such a manner that it can travel through rough and rugged terrains of palm plantations.

- To design a mechanism for spraying and managing parameters like area of spraying, deliver a herbicide/fertilizer, spraying tank on it and pass across the planation.
- To control pumps, serial manipulator, camera and spraying robot remotely using mobile application.

1.4 Herbicides Spraying

The herbicides have a vital influence of the agribusiness. Nearly 35% of crops have been safeguarded from the insects and unwanted using pesticides and herbicides. The herbicides are needed for agriculture field to increase the efficiency, but they are also injurious to human and to the environment [5]. In the current methods, the farmers use the backpack sprayer which is manually operated by the human along the crop fields [8]. They used to spray the pesticides in the targeted way manually [9]. Here the sprayer is connected to the back of the tractor and this tractor was driven by the human. The pesticides were sprayed to the crops along the field. This method does not use the selective spraying and the pesticides are spread to the field [11].

Figure 2 Manual Spraying using Knapsack Sprayer

Despite the utilization of herbicide assurance gear (individual head veil and focal filtration framework for the manual and automated spraying strategies, separately) the human is yet presented to unsafe pesticides that can cause negative medical problems [16]. Other than wellbeing concerns, automated and manual spraying strategies have different downsides [7]. The motorized spraying isn't target explicit and is intended to splash a harvest strip with rearranged stature (e.g., for spraying only the grape bunches the rancher will show the shower spouts to shower a strip 0.5 m wide with no thought of the natural product area) [10].

Moreover, manual spraying is repetitive work, moderate, and restricted because of the absence of laborers horticulture [12].

1.5 Precision Agriculture

Precision agriculture (PA) is the science of improving crop yields and assisting management decisions using high technology sensor and analysis tools. PA is a new concept adopted throughout the world to increase production, reduce labor time, and ensure the effective management of fertilizers and irrigation processes [8]. It uses a large amount of data and information to improve the use of agricultural resources, yields, and the quality of crops [15]. PA is an advanced innovation and optimized field level management strategy used in agriculture that aims to improve the productivity of resources on agriculture fields [19]. Thus, PA is a new advanced method in which farmers provide optimized inputs such as water and fertilizer to enhance productivity, quality, and yield [12]. It requires a huge amount of information about the crop condition or crop health in the growing season at high spatial resolution. Independently of the data source, the most crucial objective of PA is to provide support to farmers in managing their business. Such support comes in diverse ways, but the result is typically a decrease of the necessary resources [13].

Figure 3 Precision Spraying Robot

CHAPTER-2

LITERATURE REVIEW

2.1 Leaf Disease Diagnosis and Pesticide Spraying Using Agricultural Robot

Plant diseases have created an enormous post-effect scenario, according to Dr. M.G. Sumithra and G.R. Gayathiri, who proposed in their paper "Leaf Disease Diagnosis and Pesticide Spraying Using Agricultural Robot (AGROBOT)" that they can significantly reduce agricultural products in terms of both quality and quantity. Early pest detection is a major concern when it comes to sowing crops. The first phase entails careful and frequent plant observation. The damaged plants will then be identified, and images of the impacted area of the plants will be collected using scanners or cameras. The photos are pre-processed, converted, then grouped after that. These photos are then fed into the processor as input, where the CPU compares them. An automated pesticide sprayer will be employed to spray the pesticide to the detected region of the plant if the picture is impacted. If it isn't, the processors will immediately discard it, and the robot will stop working. Y.M. and Htun, N.C. (2018).

2.2 Autonomous Pesticide Spraying Robot for use in a Greenhouse

In their work "Autonomous Pesticide Spraying Robot for Use in a Greenhouse," Philip J. Sammons, Tomonari Furukawa, and Andrew Bulgin proposed. To address the current human health hazards, and engineering approach comprises spraying potentially harmful chemicals in the restricted space of a hot and steamy glasshouse. This is accomplished by creating and building a self-contained mobile robot that may be used to control insects and prevent illness in commercial greenhouses. The capacity of the platforms to maneuver themselves efficiently down the rows of a greenhouse demonstrates the efficacy of this technology. Simultaneously, the pesticide spraying system consistently covers the plants with spray in the prescribed quantities. The results showed that the robot could match the National Greenhouse Horticulture Centre's physical requirements for working in its greenhouses. The robot also met the deadlines it had set for itself due to financial constraints. The robot could drive up and down the greenhouse's rails. The rails are successfully sensed and operated by the Induction Proximity Sensors. The spraying device built by another thesis student was able to selectively spray specific plant groups in the greenhouse while passing along the tracks. The spray protection ensured that the crops received an adequate and uniform dose.

2.3 Intelligent Control in Spraying Pesticide Simulation System

Researchers Xu Chengzhi, Liu Pingzeng, Bai Xueming, Hou Yingkun, and Xu Jian titled in their article. Application of Intelligent Control in Spraying Pesticide Simulation System proposed that in this paper, a Smart control simulation model for spraying pesticides is developed based on configuration embedded software research. System designers use a range of terminals to construct the wireless network of information gathering, which is connected to an upper device through a special NC network. Information collecting at airports is accomplished by using modular system design methodologies. Intelligent control systems with additional functionalities can be easily created by integrating the top computer with various software modules. Pesticide spraying simulations that are intelligently designed develop opportunities for different new techniques and handicrafts to flourish. Approaches to measurement and control systems created based on modular structure design improve design performance, integrity, and ease of system maintenance, while also enhancing Universality in measuring and controlling. The experimental results demonstrate that the suggested system can simulate a wide range of events under natural circumstances. Besides that, it improved both the test's effectiveness and the researchers' comfort. With its high accuracy measurement and dependability in operation, the proposed method is a promising alternative to conventional measurement methods. Toutes of these can serve as steppingstones for future research into pesticide technology that is targeted and precise.

2.4 ARM- Based Pesticide Spraying Robot

According to the authors of the publication ARM-Based Pesticide Spraying Robot, Dr. S.R. Gengaje and Snehal M.Deshmukh proposed that the projected agricultural robot be implemented. In this location, the robot scans the plant indefinitely. The crop footage is captured by a wireless camera installed on a robot, which transmits it to the central station. The robot's operation is determined by the person stationed at the main station. Upon discovering that the crop is flawed, the robot will be instructed to carry out the kinetic will of that robot, which will result in pesticides being applied to the crop as soon as the user identifies the defect. This will be accomplished through the RF transceiver. In agriculture, robots are utilized for industrial purposes and harvesting. In agriculture, robots are mostly used for planting and fruit picking. Driverless tractors and sprayers are being developed to replace human labor in these tasks. The primary goal is to eliminate manual pesticide spraying on real farms, which is now occurring. Robots will replace humans, which will be accomplished by transmitting crop video to the central station. Instead, the central station uses a real-time processor to keep track of robot movements and pesticide spraying activity. This will help to limit the number of insecticides used by the plant. Such gadgets are most frequently employed to adapt agriculture to the needs of growing human populations. The ARM LPC2148 processor can be used to implement the real-time model. The device has the advantages of being fast, having great quality, being reliable, and having a low storage cost. The future context for this system will be the system's design employing robot intelligence. The size of the farm expands the capacity of the pesticide tank.

The image of a chili plant leaf is acquired with a digital camera to establish the health status of the chili plants. Zulkifli Bin Husin et al., 2014, utilized a digital camera to capture the image of a leaf and then processed the image using MATLAB software to create their final product. LABVIEW is used to construct the MATLAB GUI (Graphical User Interface). And as a result of this technique, only the diseased plants should be treated with the medication. Cheein, F.A.A. and Carelli, R. (2013)

CHAPTER 3

MODERN TOOLS USAGE

A variety of materials and tools were required during the building of the robot; the following is a list of components used:

3.1 Arduino Mega 2560 R3

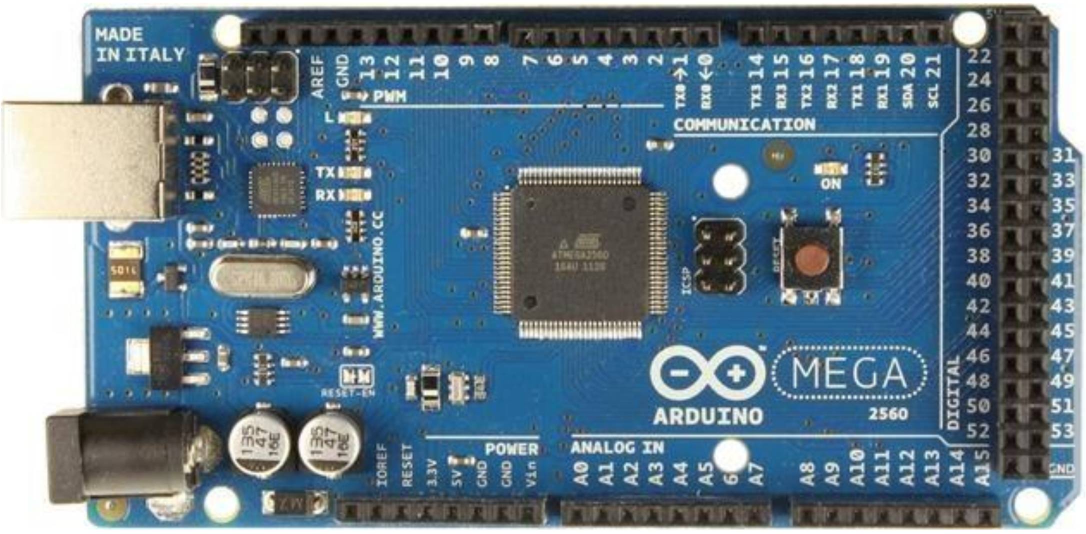

Figure 4 Arduino Mega R3

The Arduino Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. The Arduino MEGA 2560 is designed for projects that require more I/O lines, more sketch memory and more RAM. With 54 digital I/O pins, 16 analog inputs and a larger space for your sketch it is the recommended board for 3D printers and robotics projects.

3.2 Submersible Pool Water Pump 240L/H:

Figure 5 Pool water pump

A submersible water pump is a device that is connected to a motor that is entirely sealed. It's a centrifugal pump of some sort. As a result, its operation is quite like that of other centrifugal pumps. Submersible pumps are completely submerged in water. Pumps that are designed to be submerged are installed within the water reservoir that needs to be pumped out. As a result, they're frequently 9tilized for flood drainage, sewerage pumping, pond emptying, and even pond filtration. Filtration pumps are a type of submersible pump that can be found inside fish tanks.

3.3 Diode Rectifier – 1A 50V:

Figure 6 Diode Rectifier

Rectifier diodes are used in power supplies to convert alternating current (AC) to direct current (DC), a process called rectification. They are also used elsewhere in circuits where a large current must pass through the diode.

3.4 DC Motor 6V DC with Wires:

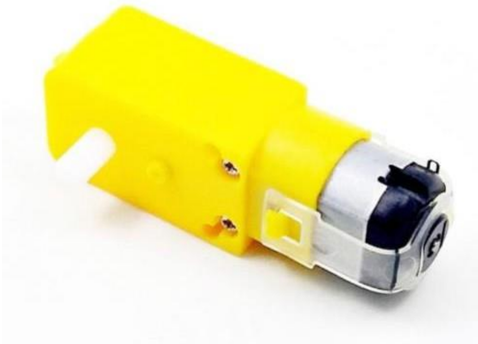

Figure 7 Dc motor

The motor draws 210mA with no load at 14500 RPM. The motor runs at 12530 RPM and draws 1.34 A at optimum efficiency (74 percent). 340 gram-cm is the stall torque. Dimensions: 24mm in diameter x 33mm in length. The motor shaft has a diameter of 2mm and a length of 10mm.

3.5 Servo – Generic Continuous Rotation (Micro Size):

Figure 8 Servo Generic Rotation

Continuous rotation servos are standard hobby RC servos that have been modified to offer open-loop speed control instead of their usual closed-loop position control. The modification effectively turns them into motors with integrated motor drivers in a compact, inexpensive package. Continuous Servo AF is any autofocus system that focuses continuously to keep a moving subject (or moving photographer) in focus, as long as the shutter is partially depressed.

3.6 Wall Adapter Power Supply:

Figure 9 Adapter Power Supply

A power supply for electronic devices. Also called an “AC adapter” or “charger,” power adapters plug into a wall outlet and convert AC to a single DC voltage. Computers use multiple DC voltages, and the power adapter is the external part of the power supply for a laptop.

3.7 Mini Pushbutton Switch:

Figure 10 Mini pushbuttons switch

The mini pushbutton is a small and cheap single pole single through switch (SPST) that can be soldered on a PCB. Usually used as a reset button, this push button closes a circuit when you press on it. It is rated at 50mA.

3.8 HC - 05 Bluetooth Serial Module:

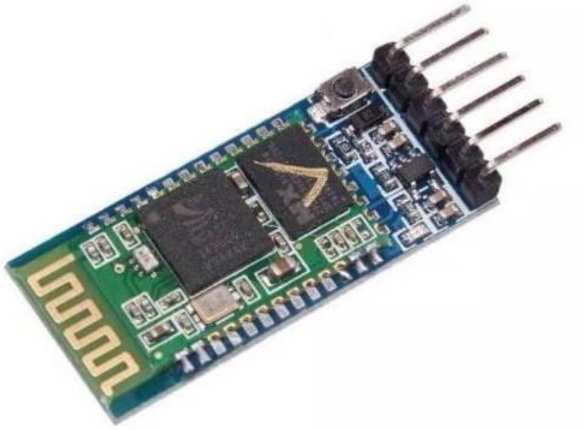

Figure 11 Bluetooth device

HC-05 Bluetooth Module is an easy-to-use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. Its communication is via serial communication which makes an easy way to interface with controller or PC.

Designed to be used instead of cable connections The HC-05 communicates with the electronics via serial communication. Typically, it is used to transmit files between small devices such as mobile phones over a short-range wireless connection. It operates at a frequency of 2.45GHz.

3.9 N-Channel MOSFET 60V 30A:

Figure 12 N Channel MOSFET

N-Channel MOSFET (metal oxide semiconductor field-effect transistor) is a type of field-effect transistor that belongs to the field-effect transistors category (FET). The capacitor is used to power MOSFET transistors. An insulated-gate field-effect transistor is another name for this type of transistor (IGFET).

Product Information:

Table 1 Production information

Manufacturer Part No	IRFZ34PBF..
Transistor Polarity:	N Channel
Continuous Drain Current Id:	30A
Drain Source Voltage Vds:	60V
On Resistance Rds(on):	0.05ohm

3.10 Voltage Regulator 5v:

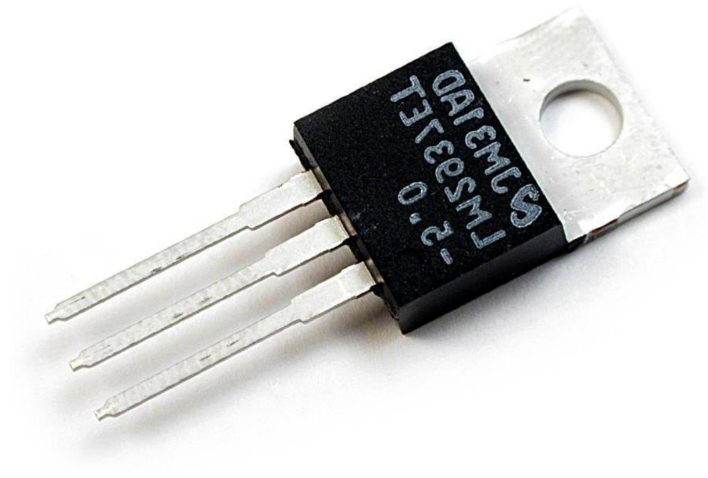

Figure 13 Voltage Regulator

Any electrical or electronic device that keeps the voltage of a power source within acceptable limits is known as a voltage regulator. The voltage regulator is required to keep voltages within the acceptable range for electrical equipment that uses that voltage. A voltage regulator generates a fixed output voltage of a preset magnitude that remains constant regardless of changes to its input voltage or load conditions. There are two types of voltage regulators: linear and switching.

3.11 Electrolytic Capacitor - 1uF/50V:

Figure 14 Electrolytic Capacitor

10 x 1F 50V 0805 non-electrolytic radial ceramic capacitors in a pack. Suitable for blocking, coupling, and by-passing capacitors in applications needing predictable property changes and reliable performance. 5.08mm pitch (0.2inch) 20 percent tolerance. Smoothing the input and output to a filter. Noise filtering or decoupling in power supplies. Coupling signals between amplifier stages. Storing energy in low power applications.

3.12 Relay Module 4-Ch:

Figure 15 Relay

The 4 Channel Relay Module is a handy board for controlling high voltage, high current loads such motors, solenoid valves, lamps, and AC loads. It's made to work with microcontrollers like Arduino, PIC, and others. Screw terminals are used to connect the relays' terminals (COM, NO, and NC).

3.13 L298N Motor Driver:

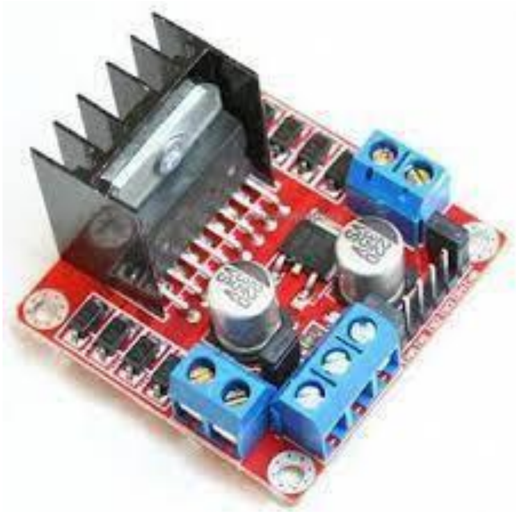

Figure 16 L298N Motor Driver

The L298N is a dual H-Bridge motor driver that allows for simultaneous speed and direction control of two DC motors. The module can power DC motors with voltages ranging from 5 to 35V and peak currents of up to 2A. L298 is a high voltage and high current motor drive chip which receives TTL logic signals. It is needed to operate different loads like motors and solenoid etc where an H-Bridge is required. High power motor driver is required.

CHAPTER-4

4.0 Conceptual Design and Evaluation

We used 4-5 conceptual ideas to come up with concepts for our Remote Operated Herbicide Sprayer. Each team member was asked to come up with hir/her own idea for one of the major designs. After that, the designs proposed by the team member we discussed among the group to finalize the final design. Parameters like performance, appearance, cost, customer satisfaction and spraying mechanism were discussed to finalize the robot. To choose the final design of our robot all designs proposed by the group members were compared to other members design to choose the best design and few implementations were made to make our robot suitable for our requirements.

4.0.1 The Chassis

As we know the entire weight of the robot will be supported by the chassis hence, we had to choose a chassis which is affordable and cost effective. We choose chassis made of 'Acrylic' and our chassis is made of 3-levels to support the weight of the robot. The first level was mounted with battery, the second level with the components and third level with tanks and serial manipulator. To support each level, we used metal bearings and mounted the chassis on the bearings.

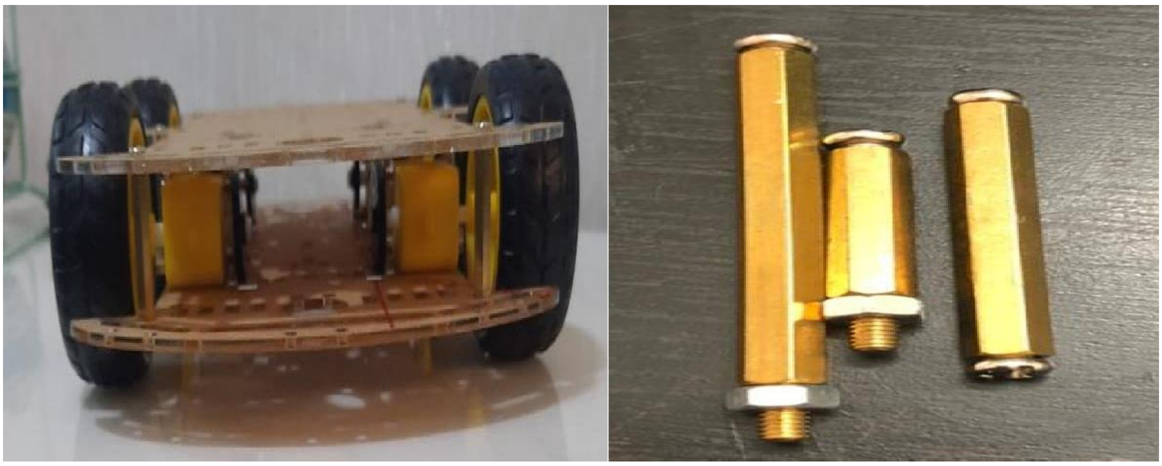

Figure 17 Chassis and bearings used to support

4.0.2 Selection of Motors and Wheels

The DC Motors with high torque and high speed are selected as these motors must bear the weight of the entire setup and move it according to our command. The motor with Nut is preferred as it can be easily fitted at any desired location. Since the wheel has to bear the weight of the entire setup, and the model has to traverse through adverse terrains, the wheel has to be sturdy, gripping and of moderate size. Considering the above aspects, the selection of wheel has been done.

Table 2 Specs of Motor

Specification	Dimensions
Shaft dia	0.145 in
Shaft Length	1.46 in
Speed	14500RPM
Torque	93 Nm

Table 3 Specs of Wheels

Specification	Dimensions
Wheel dia	15 in
Wheel Width	4.5 in
For Axle dia	0.145 in
Style	Tubeless
Pressure capacity of Wheel	4.06 MPa

4.0.3 Storage of Tanks

In our we have considered to use 3 tanks of 1litre each, one tank stores water with DC pump in it, one tank stores herbicide with DC motor in it and other tank is used to mix both water and herbicide and one more DC pump is placed in third tank. A hose from pump of third tank is connected to Nozzle with the support of serial manipulator in order to spray the mixture. The storage tank is designed in such a way that it fits exactly on top of the robot so that its easy to refill the liquids. Material chosen for the tanks is plastic so that the weight of the tank can be less.

4.1 AutoCAD Design

Below figure shows the finalized robot CAD design. This robot consists of 3 tanks and uses Arduino Mega R3 as its controller. We have serial manipulator to support our spraying mechanism. The serial manipulator can move in 4 directions to spray efficiently. The robot is designed in a such way that it can move with ease in any terrain and can a load of 4kgs. The robot design is simple and cost effective at same time.

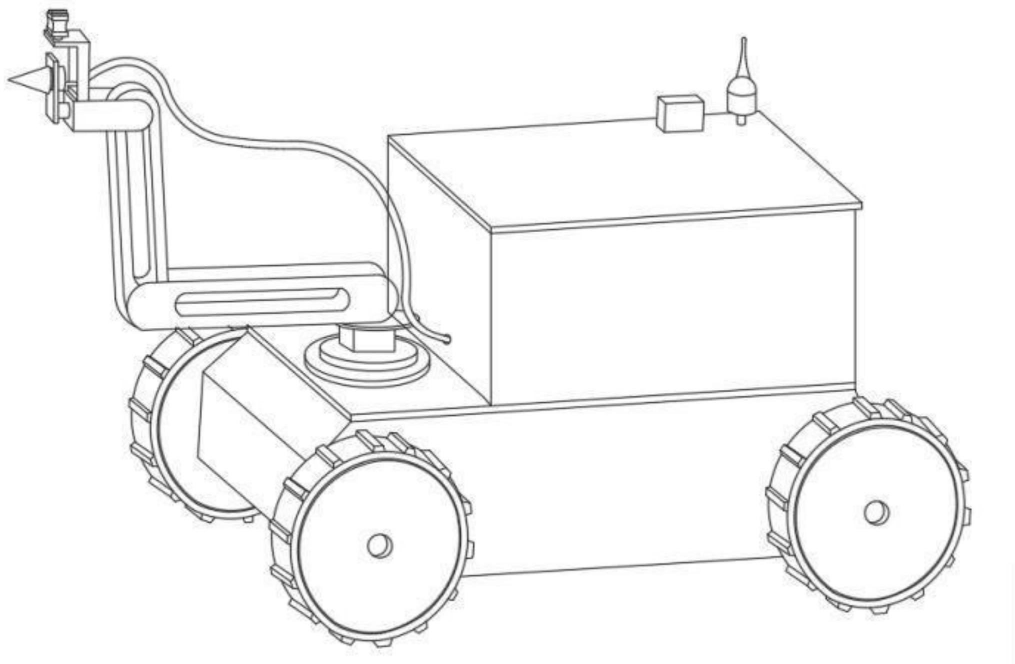

Figure 18 AutoCAD Design of spraying robot

4.2 Spraying Mechanism of System

The spraying of the chemical is designed to precision spray all over the plant evenly. For this to happen we have used wooden serial manipulator with two servo generic rotation motors which allows the manipulator to move and spray in all four directions. The rate of spraying can be controlled by controlling the voltage level of the pump through Arduino.

Considerations of Spraying System:

- Precision spraying.
- Able to spray in all four directions.
- Angle at which the manipulator moves.
- Height at which the manipulator operates in order to maintain pressure of the pump.

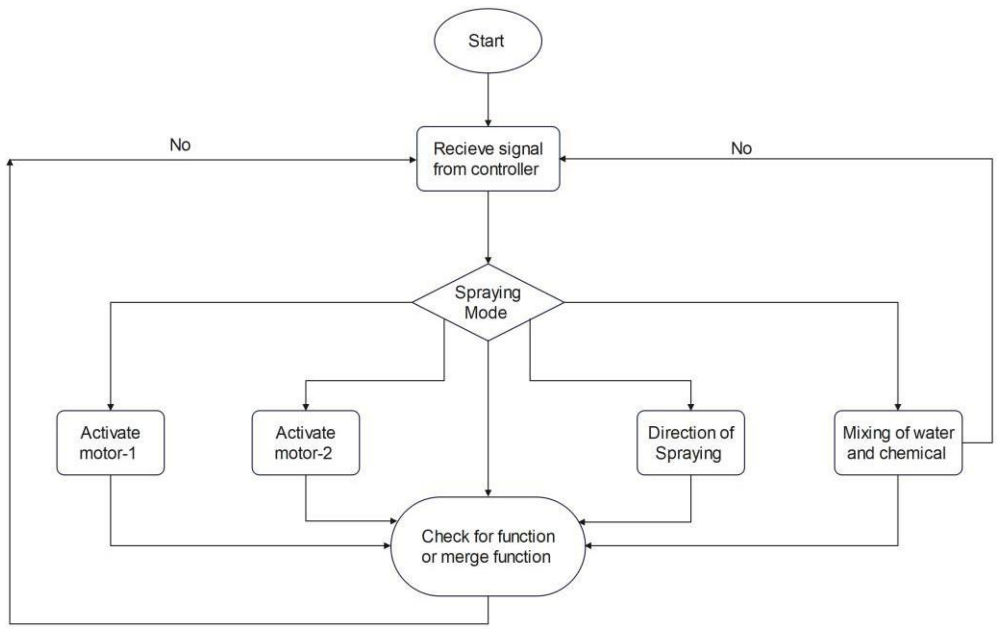

Figure 19 Program flowchart of Spraying System

4.3 Team Brainstorming

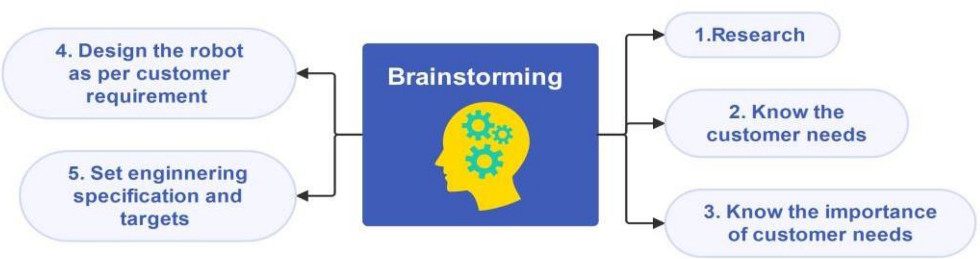

Figure 20 Brainstorming

4.3.1 Research

The key step to begin to build any kind of robot or prototype is to do research on the title. By doing research we get to know what kind of technology is being used in the market. We can understand which area to focus more while building the prototype.

4.3.2 Know the Customer Needs

By knowing the customer needs we get the idea of what customer in keen about, and then we can design the robot as per customer requirement.

4.3.3 Know the importance of customer needs

The relevance of customer request is assessed in this step. This can be done by calculating a weighting factor. This will give you an estimate of how much time, effort, and money you'll require to meet each need. The following table contains the relevant information.

Table 4 Customer Requirements

Parameters	Requirements
Technology	- Robot must meet the current tech being used in the market - Design should be unique
Operation	- Must be able to operate remotely using mobile application
Costing	- The robot be affordable and reliable
Spraying mechanism	- Should be able to spray in areas where humans can't reach
Performance	- The robot must be able to move in all directions of the plantation.
Battery Efficiency	- The robot should be able to operate for at least 3hrs - The battery should be rechargeable
Capacity	- The robot able to support weight up to 4kgs and should be carry this weight in plantation
Automation	- Able to operate using remotely - Mix water and herbicide automatically

Table-4: Customer Requirements

4.3.4 Design the robot as per customer requirement

After knowing the customer needs the designing of the robot is done as per stated by the customers. Once the prototype is ready should be tested for more three times to find any faults in the robot while operating.

Table 5 Engineering Specs of Robot

Parameters	Engineering Specification Description	Comments
Technology	Tech used	Use of latest technology
Operation	Functional and efficient	Remotely operated
Costing	Low cost	-
Spraying mechanism	Angles of spraying Operational time	≤15mins
Performance	Proactive robot	Moves swiftly
Battery Efficiency	Source of power	Rechargeable
Capacity	Endurance of robot	≤5kgs
Automation	Automated	-

4.3.5 Set engineering targets and specifications

The size, weight and spraying are the most important factors of our engineering specifications. This allows us to understand that the customers are interested towards the design and specifications of the robot. Below table shows the targets set.

4.4 Mind Mapping

Once we grasp the relationship between the customer's requirements and engineering specifications, we can develop a Mind Mapping diagram in which the solution to each problem is drawn in an easy-to-understand diagram. To accomplish so, we can look into the functional aspects of the Spraying Robot's entire problem. We can then find solution to each issue, which will eventually lead to a solution to the broader problem. The robot system can then be divided into spraying and movement mechanisms. Aside from that, there are several purposes such as reliability, convenience, and product improvement. Dependability refers to a robot ability to execute its needed function during a given operational term. In this case, the prototype must be safe and show when the spraying is finished. Battery monitoring alert should be included with the other safety feature. Portability, ease of installation, and control are all important factors in ensuring convenience. The size of the robot is referred to as probability. The design should also be simple to construct and disassemble, saving the operator time and effort. It is also necessary for the robot to be easily operated by all robots in order to cover all areas. This device should be built in such a way that future updates are possible. There will be a major function for product enhancement, which is the ability to convey herbicide and water.

4.5 Concept Evaluation or Scoring method using Decision Matrix

This part focuses on evaluating the design concept through the consideration of each design's constraints and the use of the Decision Matrix. The goal is to use the fewest resources possible while determining which concepts have the best chance of becoming high-quality products. A Decision Matrix has been created to aid in the selection of the best concept by allowing for the best comparison of matching the previously specified parameters.

Table 6 Scoring Method using Decision Matrix

Parameters	**Weightage**	**Model-1**	**Model-2**	**Model-3**	**Model-4**
Technology	6	-	-	+	-
Operation	10	-	+	+	-
Costing	10	+	-	+	+
Spraying Mechanism	8	-	-	+	+
Performance	8	+	+	+	+
Battery Efficiency	6	+	+	-	+
Capacity	10	+	+	+	-
Automation	8	-	+	+	+
Materials used	5	+	+	+	+

Total Scoring (+)	38	39	47	65	45
Total Scoring (-)	32	32	24	6	26
Total Count	6	7	23	59	19

CHAPTER 5

DESIGN/DEVELOPMENT OF SOLUTIONS

5.0 Proposed System

Herbicide spraying and fertiliser scattering are tedious applications. Despite the fact that pesticide spraying is now required, farmers still find it to be a hazardous process. This project is based on the development of an agricultural robot vehicle that navigates between crops using an Android application based on the farmer's instructions. This truck has lower-cost components, making it more cost-effective. To move the robot in the field, the farmer can use any Android smart phone with this application. Through an IoT application, farmers can control pesticide sprinkling devices. This low-cost robotic vehicle would increase efficiency, safety, and meet labour demand in agricultural applications.

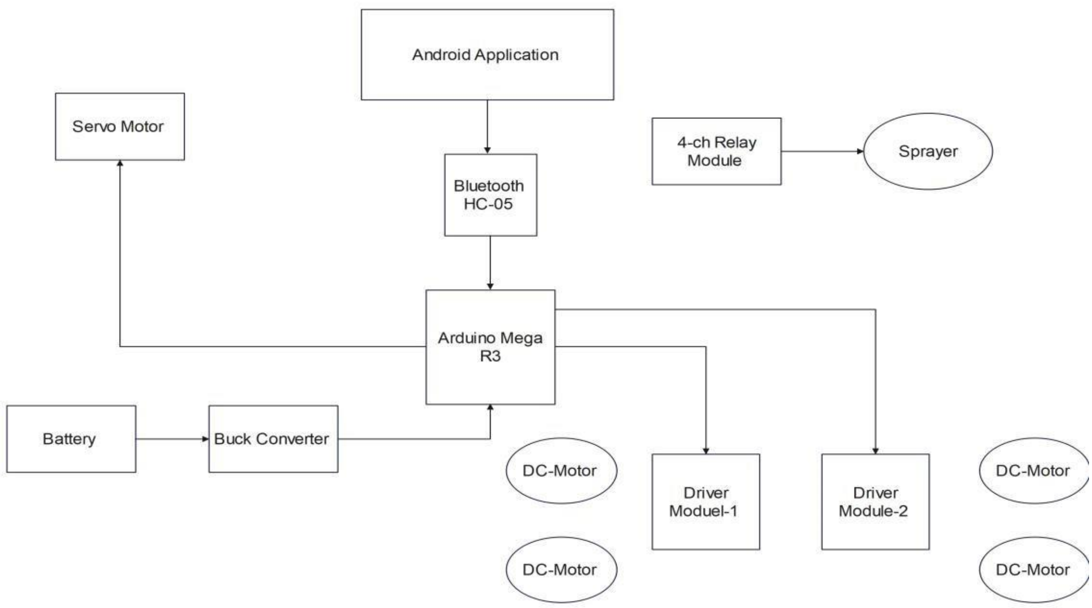

Figure 21 System Architecture

5.1 Description of Proposed System Components

We build the android application to control this spraying rover. Firstly, we have to connect the android application with HC-05 Bluetooth module to control all hardware components of spraying rover. Once we connect Bluetooth, we can easily control this spraying rover. In this rover, we attached four brushless DC motors with L293D motor driver. The connection of the microcontroller, Arduino Uno, brushless DC motor through brushless motor driver and received the power supply from 12V battery. The motor drivers can manipulate the rotation of the motor using its phase connected to the gate driver MOSFET on its circuit. Another servo motors are also used here to control sprayer part of this rover. A servomotor is a rotary or linear actuator that can control angular or linear position, velocity, and acceleration with precision. The main purpose of this servo motors is to move the sprayer according to the user's requirement. We used this servo motors as shoulder part to move the sprayer accordingly. Arduino uno board receive commands from android application and works accordingly. In this system we used 6V pump, the pump is connected with Arduino and passes through buck convertor and relay module which helps to control high voltage pump. A relay is a switch that is regulated electrically by an electromagnet. A low voltage, such as 5 volts from a microcontroller, activates the electromagnet, which pulls a contact to make or break a high voltage circuit. Here, we used 12V battery that is high, so to convert that high voltage DC current to low voltage DC we used buck converter here. From the input to the output, a Buck converter steps down a DC voltage. The operation of the circuit is determined by the MOSFET's conduction state.

5.2 Controlling Strategy

An application was designed to control the robot remotely; the application user has full control of the robot operation, such as spraying, driving, and changing the spraying direction. Figures 1,2 and 3 shows the application used on a smartphone.

Figure 22 Driving buttons on the smartphone application

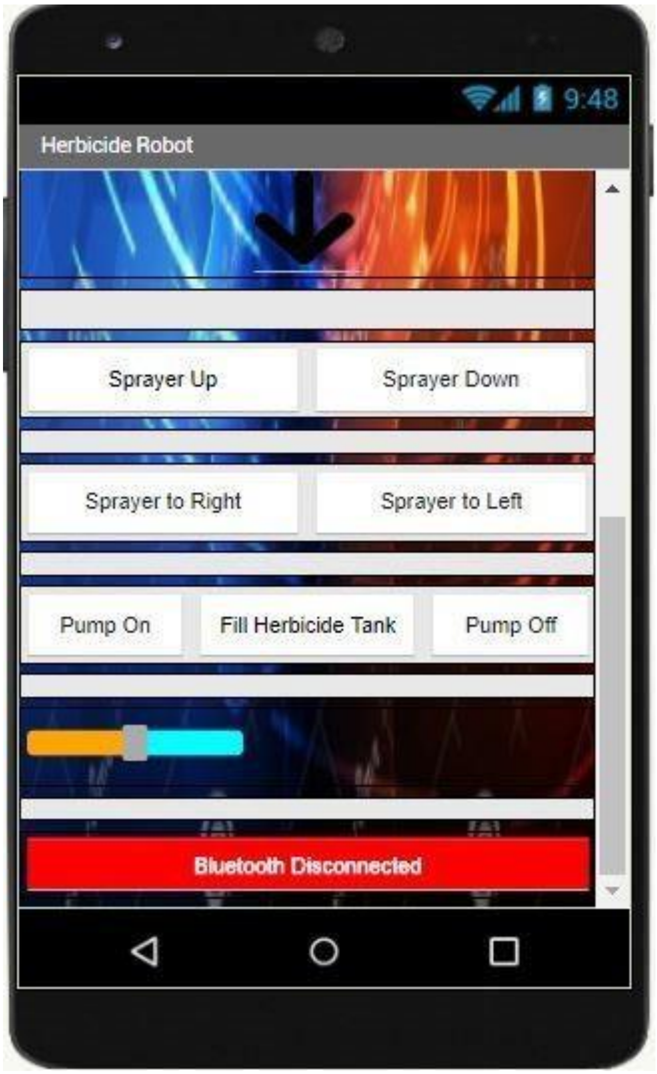

Figure 23 Pump and spraying buttons on the smartphone application

A third-party programme called "MIT App Inventor" came up with the idea for the implementation. The following is a step-by-step breakdown of how the application must be.

1. Visit "ai2.appinventor.mit.edu" and click the "Create" button in the upper right corner.

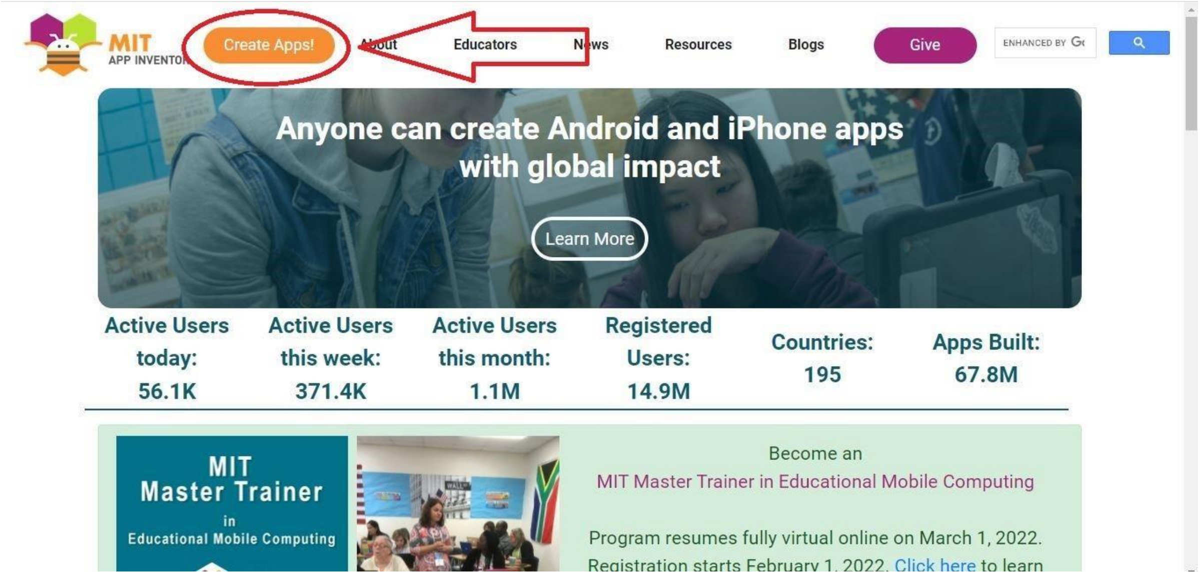

Figure 24 First step of the application design

2. Create New Project

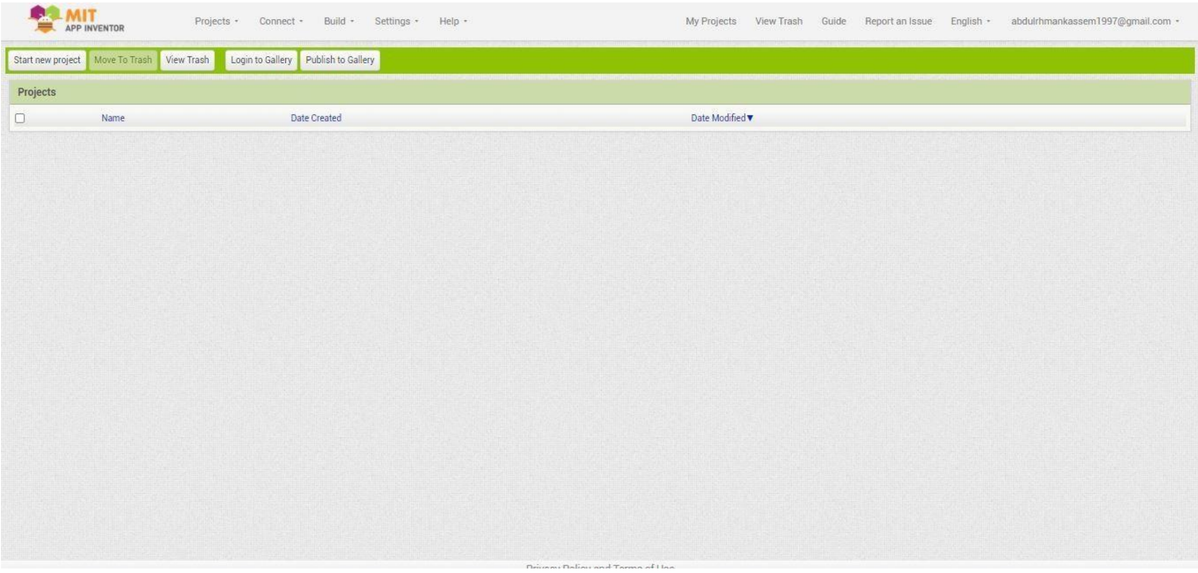

Figure 25 Second step of the application design

3. Name of the project

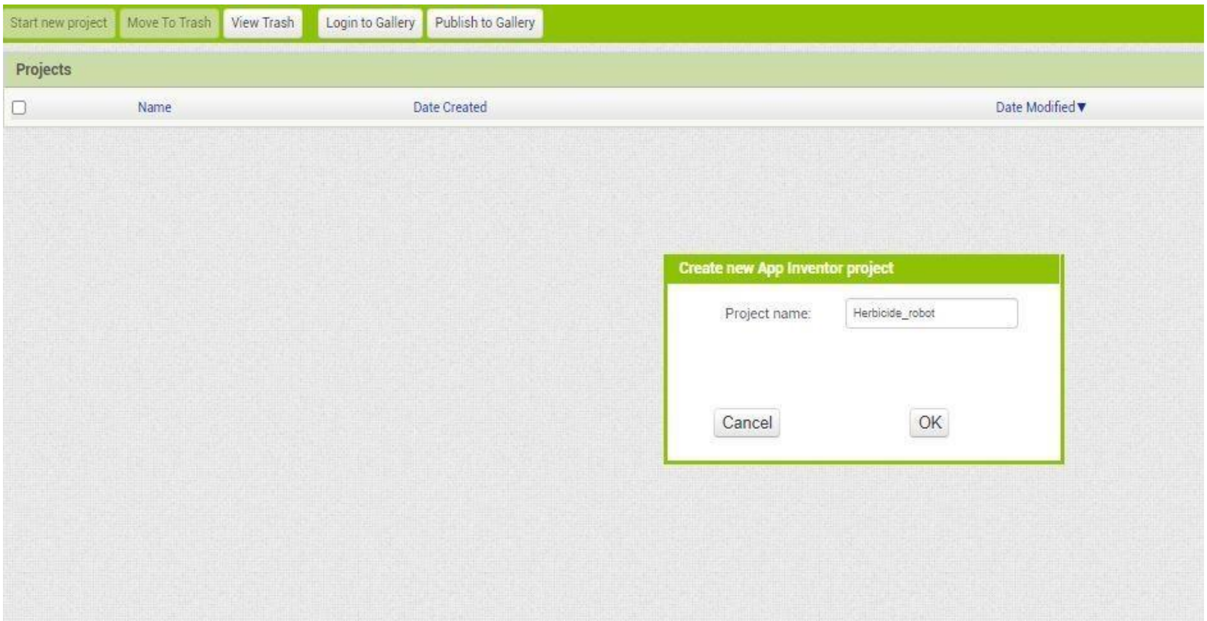

Figure 26 Third step of the application design

4. The Design workspace, often known as the "Designer," is where the user defines the app's appearance and functionality. Users choose user interface elements like Buttons, Pictures, Text Boxes, and programmes like Text-to-Speech, Sensors, and GPS.

Figure 27 Fourth step of the application design

5. Students added several buttons to operate the automobile in this project, and the Bluetooth module had to be set up as well. Users may customise their application while setting up the components to make it more user-friendly. Finally, the students came up with the design below.

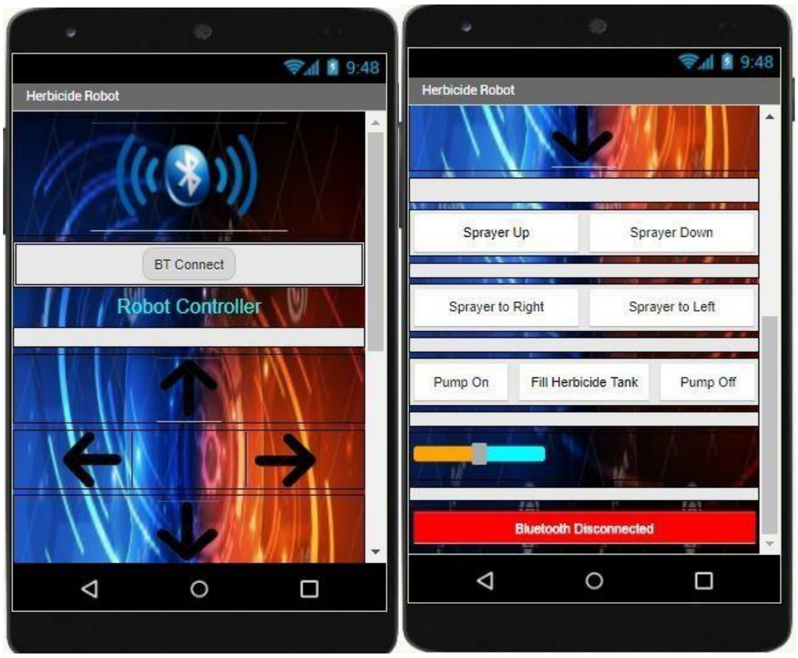

Figure 28 Fifth step of the application design

6. Users must also design their blocks by dragging the commands from the software itself and programme each button to allow the user to have complete control of the robot using the application.

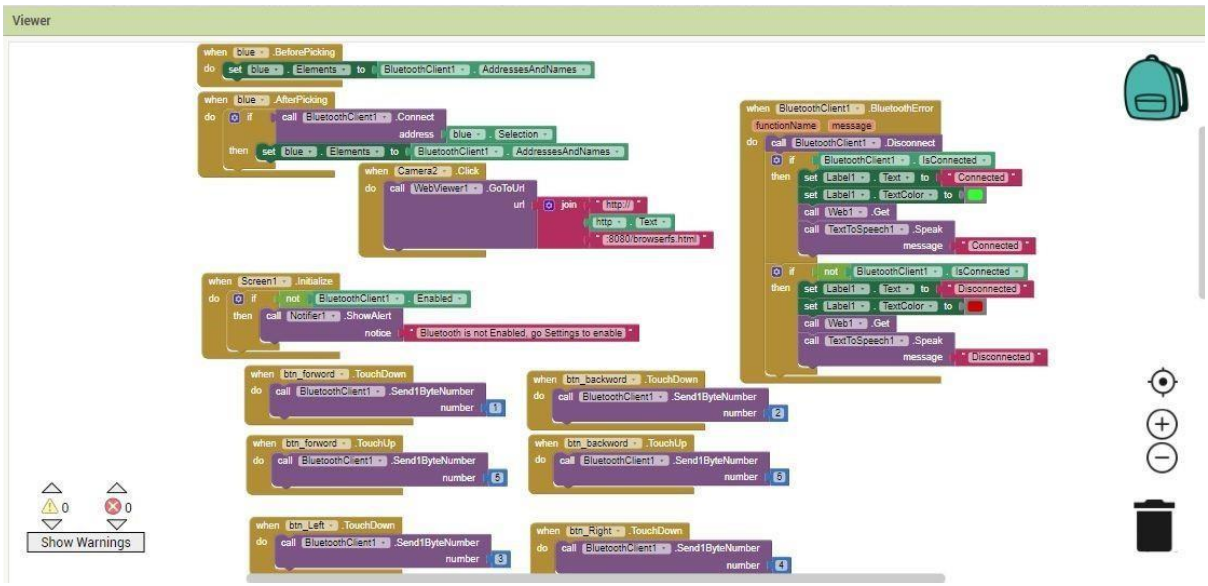

Figure 29 Sixth step of the application design

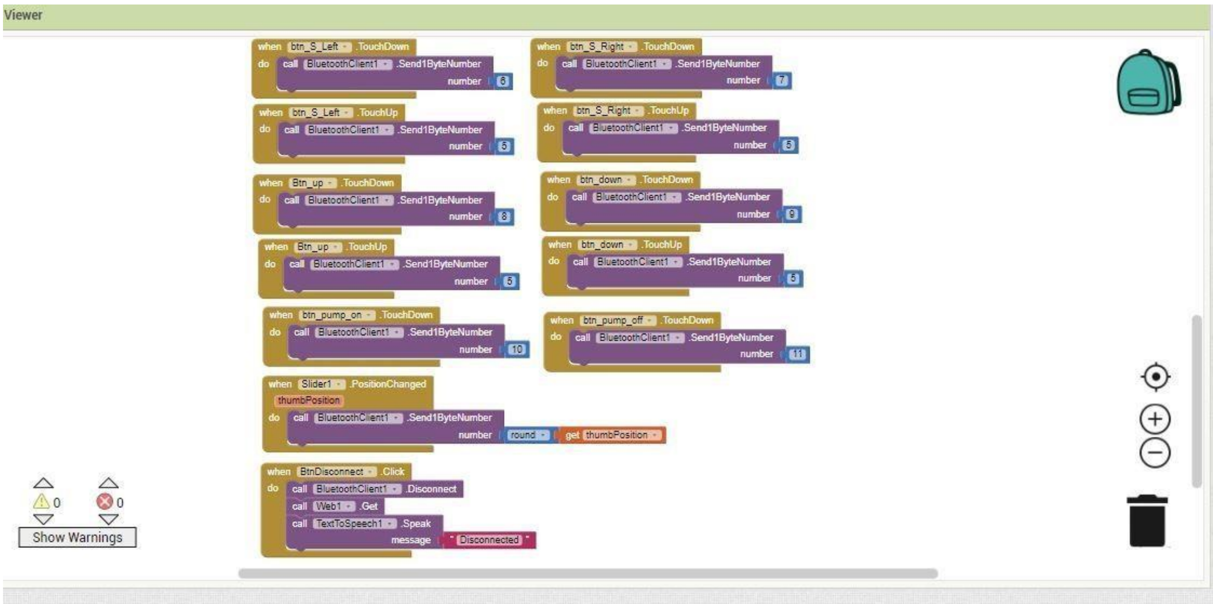

Figure 30 Sixth step of the application design

7. Connect the smartphone to the application. One of the wonderful things about "MIT App Inventor" is that the user can view and test the app while it's being designed on the computer.

8. Start AI companion on the smartphone

To begin the software, press the "MIT AI Companion" button on the smartphone or tablet in use. NOTE: The phone and the device must be connected to the same wireless network, and the user must assure that the phone's Wi-Fi is connected to the same network.

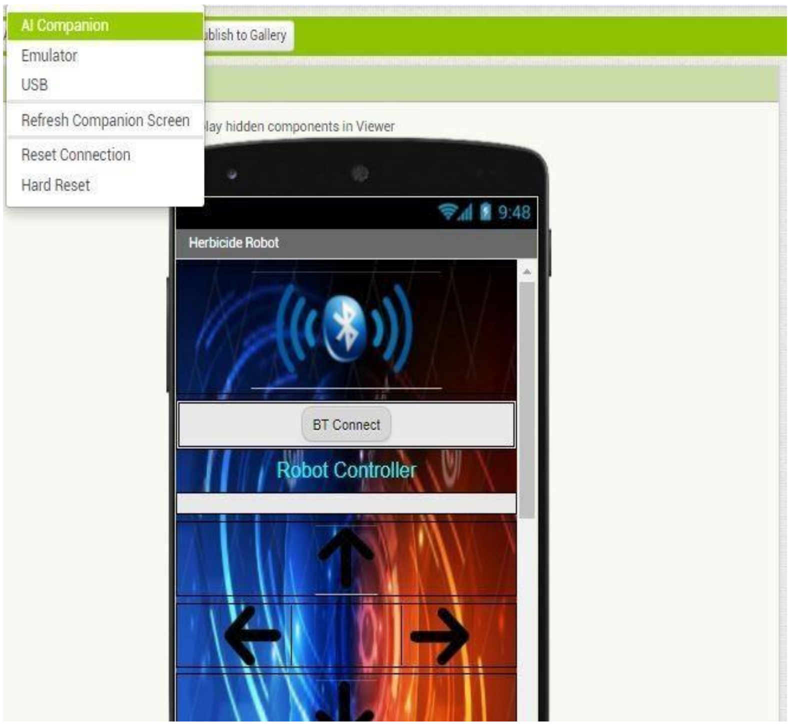

Figure 31 Seventh step of the application design

9. Finally, on the utilised device, open the MIT AI2 Companion and scan the barcode or type in the code to connect for live testing of the developed app.

Figure 32 Last step of the application design

5.3 DESIGN STRATEGY

Autodesk AutoCAD, the educational version for students, was used to create the prototype's overall structure and body. Here are some photos of the prototype taken from various perspectives.

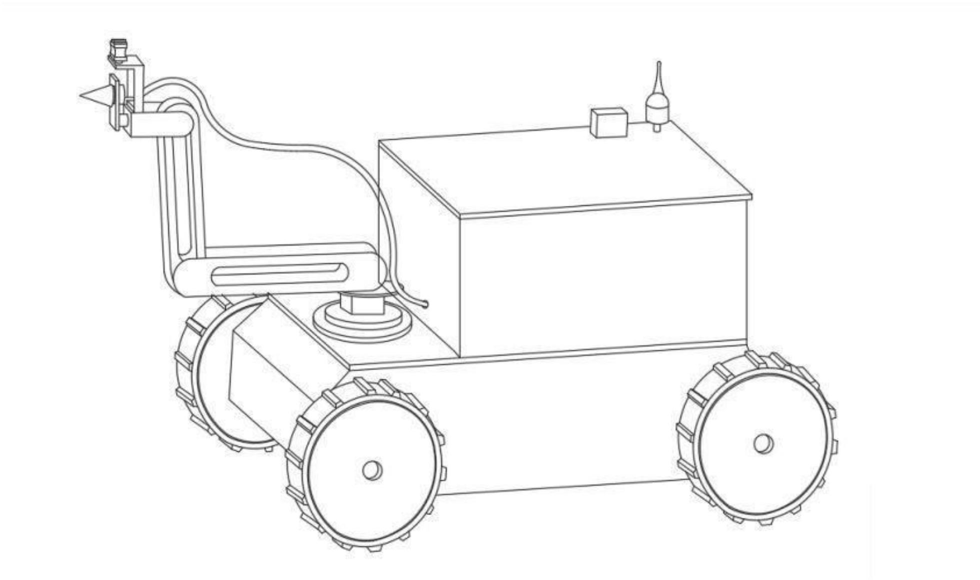

Figure 33 Herbicide Robot Structure

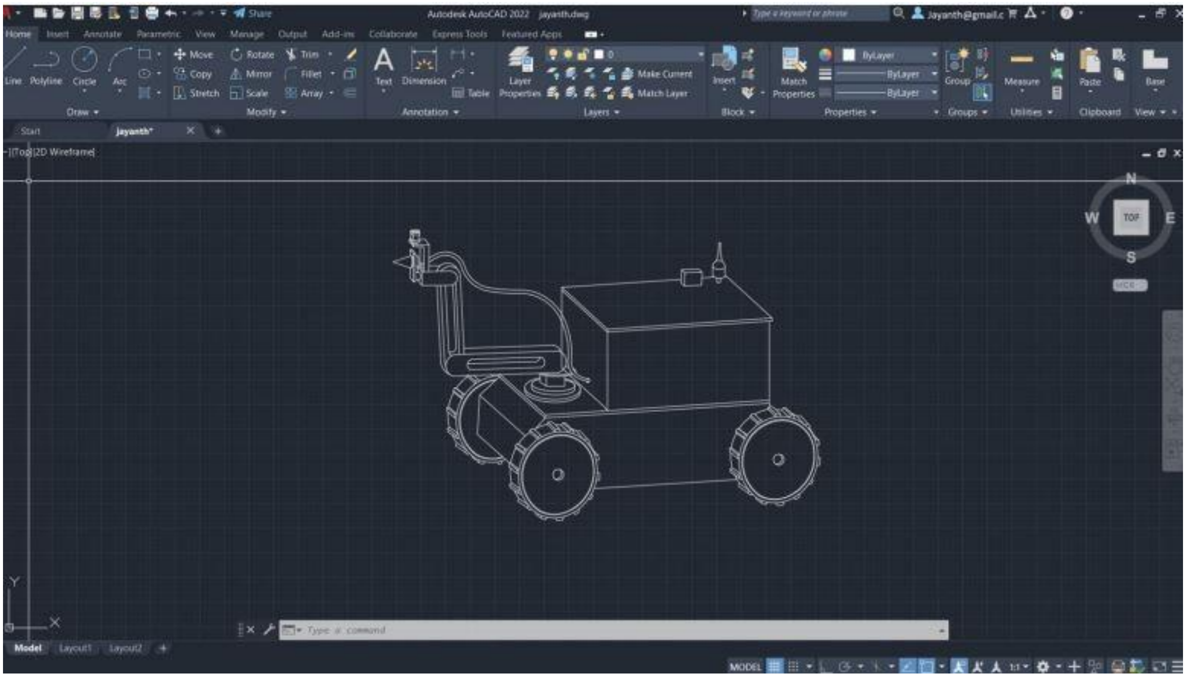

Figure 34 Herbicide Robot Structure

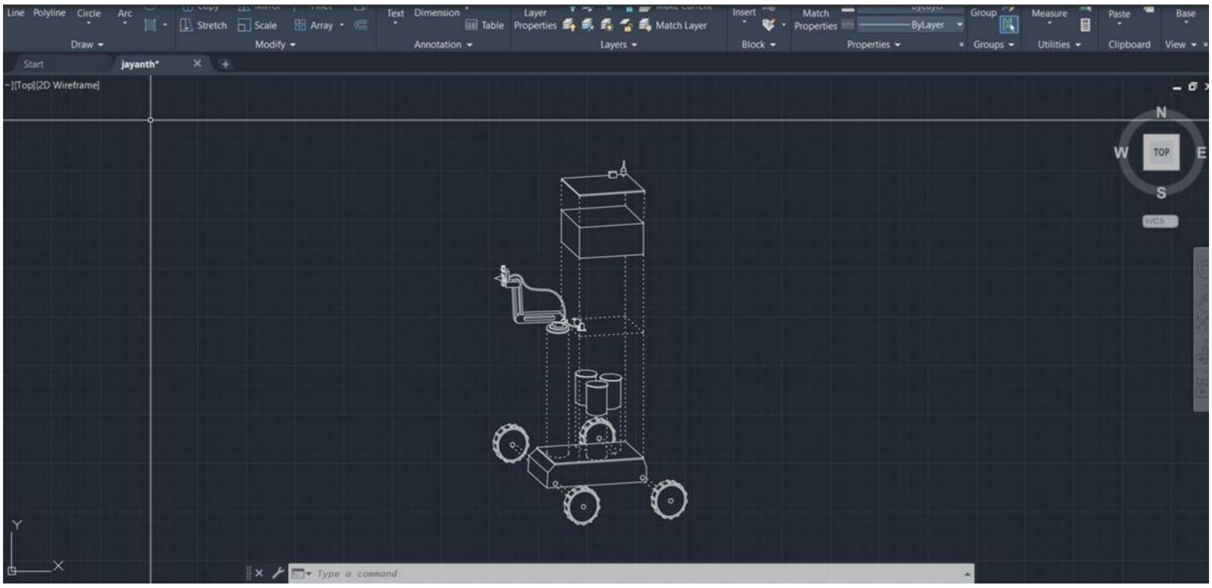

Figure 35 Herbicide Robot Axonometric view

5.4 MAIN CONTROLLER AND CODING

As previously stated, the Arduino Mega 2560 Pinout serves as the project's primary controller. The code was successfully developed and tested.

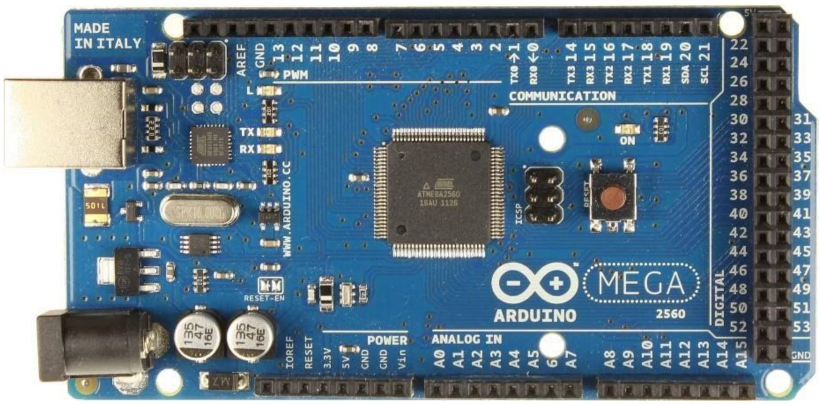

Figure 36 Main Controller

5.5 ARDUINO CODE

The following code covers the general controlling mechanism of the motors attached to the prototype, all pins and ports are described, and the code was successfully run and uploaded.

```
#include <Servo.h>
#include <SoftwareSerial.h>
SoftwareSerial BT(A10, A11);

Servo servo_Motor1;
Servo servo_Motor2;

int Motor_Right1_1 = 34;
int Motor_Right1_2 = 35;

int Motor_Left1_1 = 36;
int Motor_Left1_2= 37;

int Motor_Right2_1 = 30;
int Motor_Right2_2 = 31;

int Motor_Left2_1 = 32;
int Motor_Left2_2= 33;


int state;
int speed = 200;

int positon1 = 90;
int positon2 = 90;

int Pump_Motor1 = 13;
```

Figure 37 Arduino Code of the prototype

```
int Pump_Motor2 = 38;


int Pump_Motor3 = 44;

int pwm1 = 8;
int pwm2 = 9;
int pwm3 = 10;
int pwm4 = 11;


void setup(){
servo_Motor1.attach(2);
servo_Motor1.write(positon1);
servo_Motor2.attach(3);
servo_Motor2.write(positon2);

pinMode(Motor_Right1_1, OUTPUT);
pinMode(Motor_Right1_2, OUTPUT);

pinMode(Motor_Left1_1, OUTPUT);
pinMode(Motor_Left1_2, OUTPUT);

pinMode(Motor_Right2_1, OUTPUT);
pinMode(Motor_Right2_2, OUTPUT);
```

Figure 38 Arduino Code of the prototype

```
pinMode(Motor_Left2_1, OUTPUT);
pinMode(Motor_Left2_2, OUTPUT);



pinMode(Pump_Motor1, OUTPUT);
pinMode(Pump_Motor2, OUTPUT);
pinMode(Pump_Motor3, OUTPUT);

pinMode(pwm1, OUTPUT);
pinMode(pwm2, OUTPUT);
pinMode(pwm3, OUTPUT);
pinMode(pwm4, OUTPUT);



// initialize serial communication at 9600 bits per second:
Serial.begin(9600);
BT.begin(9600); // Setting the baud rate of Software Serial Library

 delay(100);
 }

void loop(){
//if some date is sent, reads it and saves in state

if(BT.available() > 0){
```

Figure 39 Arduino Code of the prototype

```
state = BT.read();
Serial.println(state);
if(state > 15){speed = state;}
}


     if (state == 1){forword();Serial.println("The motor will go forward");}

else if (state == 2){backword();Serial.println("The motor will Backword!");}

else if (state == 3){turnLeft();Serial.println("The motor will turn left");}

else if (state == 4){turnRight();Serial.println("The motor will turn rightT");}

else if (state == 5) {stop();Serial.println("STOP!");}

else if (state == 6) {Serial.println("lift");  if(positon1<180){positon1 = positon1+1;}}
else if (state == 7) {Serial.println("right"); if(positon1>0){positon1 = positon1-1;}}
else if (state == 8) {Serial.println("up");    if(positon2>0){positon2 = positon2-1;}}
else if (state == 9) {Serial.println("down");  if(positon2<180){positon2 = positon2+1;}}


else if (state == 10){Serial.println("pump on");digitalWrite(Pump_Motor1, LOW);

digitalWrite(Pump_Motor2, LOW);
digitalWrite(Pump_Motor3, HIGH); }
```

Figure 40 Arduino Code of the prototype

```
else if (state == 11){Serial.println("pump off");digitalWrite(Pump_Motor1, LOW);
digitalWrite(Pump_Motor2, LOW);
digitalWrite(Pump_Motor3, LOW);}


 else if (state == 12){Serial.println("pump off");digitalWrite(Pump_Motor1, HIGH);
 digitalWrite(Pump_Motor2, HIGH);}
servo_Motor1.write(positon1);
servo_Motor2.write(positon2);
analogWrite(pwm1, speed);
analogWrite(pwm2, speed);
analogWrite(pwm3, speed);
analogWrite(pwm4, speed);
}
void stop(){
    digitalWrite(Motor_Right1_1, LOW);
    digitalWrite(Motor_Right1_2, LOW);

    digitalWrite(Motor_Left1_1, LOW);
    digitalWrite(Motor_Left1_2, LOW);

    digitalWrite(Motor_Right2_1, LOW);
    digitalWrite(Motor_Right2_2, LOW);

    digitalWrite(Motor_Left2_1, LOW);
    digitalWrite(Motor_Left2_2, LOW);
```

Figure 41 Arduino Code of the prototype

```
void forword(){

    digitalWrite(Motor_Right1_1, LOW);
    digitalWrite(Motor_Right1_2, HIGH);

    digitalWrite(Motor_Left1_1, HIGH);
    digitalWrite(Motor_Left1_2, LOW);

     digitalWrite(Motor_Right2_1, HIGH);
    digitalWrite(Motor_Right2_2, LOW);

    digitalWrite(Motor_Left2_1, LOW);
    digitalWrite(Motor_Left2_2, HIGH);
}

void backword(){
    digitalWrite(Motor_Right1_1, HIGH);
    digitalWrite(Motor_Right1_2, LOW);

    digitalWrite(Motor_Left1_1, LOW);
    digitalWrite(Motor_Left1_2, HIGH);

    digitalWrite(Motor_Right2_1, LOW);
    digitalWrite(Motor_Right2_2, HIGH);

    digitalWrite(Motor_Left2_1, HIGH);
```

Figure 42 Arduino Code of the prototype

```
void turnRight(){
    digitalWrite(Motor_Right1_1, HIGH);
    digitalWrite(Motor_Right1_2, LOW);

    digitalWrite(Motor_Left1_1, HIGH);
    digitalWrite(Motor_Left1_2, LOW);

    digitalWrite(Motor_Right2_1, HIGH);
    digitalWrite(Motor_Right2_2, LOW);

    digitalWrite(Motor_Left2_1, HIGH);
    digitalWrite(Motor_Left2_2, LOW);
}

void turnLeft(){
    digitalWrite(Motor_Right1_1, LOW);
    digitalWrite(Motor_Right1_2, HIGH);

    digitalWrite(Motor_Left1_1, LOW);
    digitalWrite(Motor_Left1_2, HIGH);

    digitalWrite(Motor_Right2_1, LOW);
    digitalWrite(Motor_Right2_2, HIGH);

    digitalWrite(Motor_Left2_1, LOW);
    digitalWrite(Motor_Left2_2, HIGH);
}
```

Figure 43 Arduino Code of the prototype

5.6 ELECTRICAL HARDWARE AND CIRCUIT DESIGN

The control system for the Herbicide Robot is shown schematically below. The software Proteus 8 Professional was used to build it.

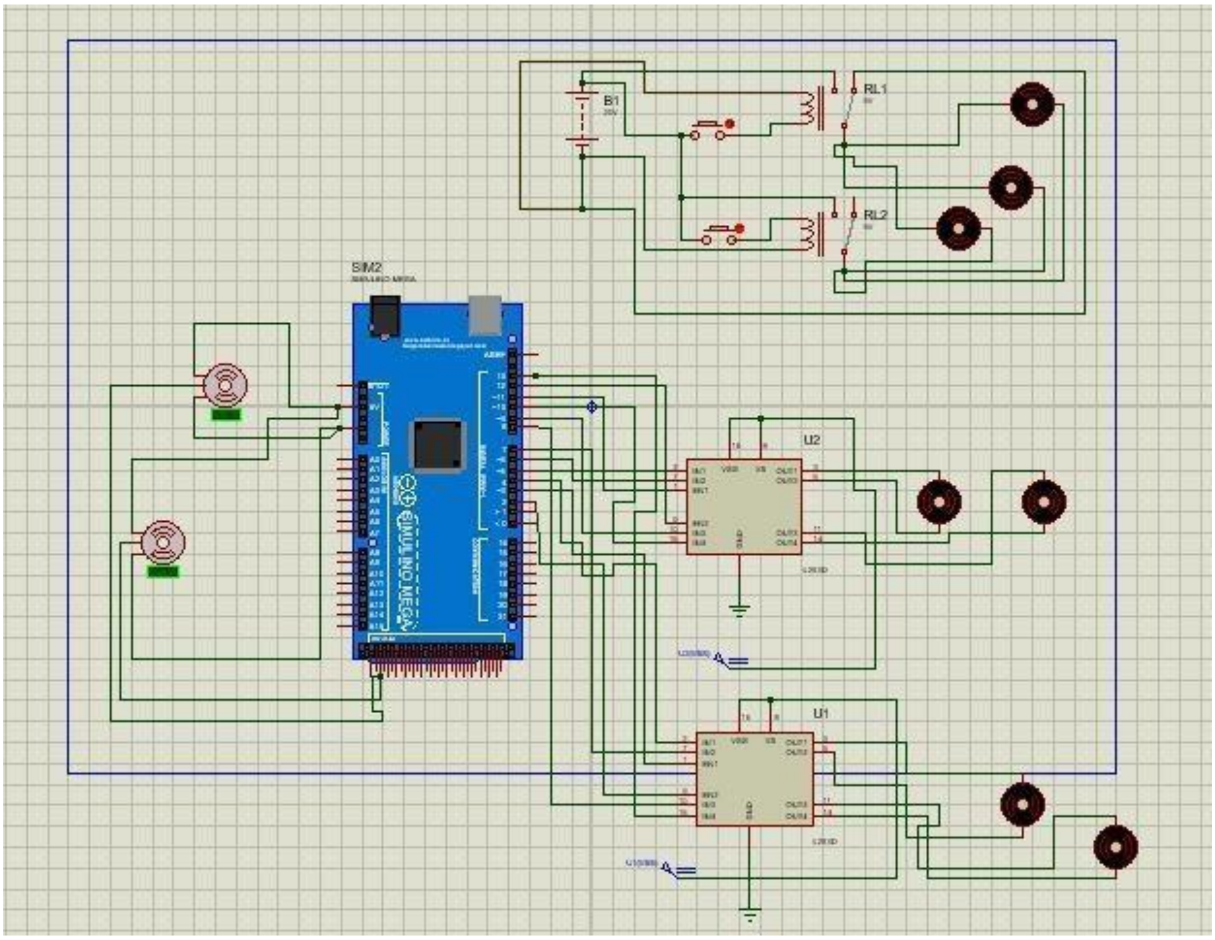

Figure 44 Schematic Diagram

Once the circuit design was completed and tested, students could proceed to build up the circuit.

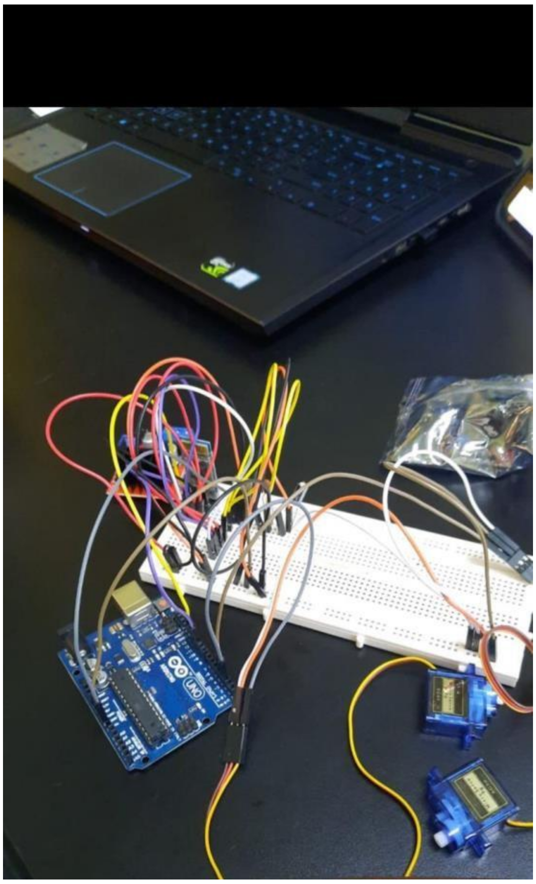

Figure 45 Circuit Contraction

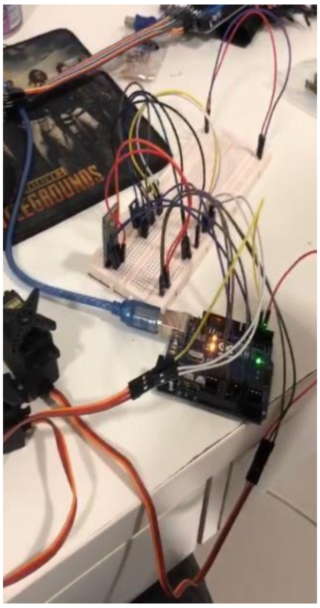

Figure 46 Circuit Construction

5.7 Costing or Budgeting of the robot

Table 7 Costing of the robot

Components	Quantity	Price/Unit (RM)	Total Price (RM)
Arduino Mega R3	1	180	180
Water Pump 240L/H	2	14.72	29.44
Diode Rectifier (1A/50V)	4	1.24	4.96
DC Motors 6V	4	19.34	77.36
Servo Generic Rotation	2	29	58
Wall Adapter Power Supply	1	21.02	21.02
Mini Pushbutton Switch	1	1.24	1.24
Bluetooth (HC-05)	1	13.90	13.90
N-Channel MOSFET 60V/30A	1	6.05	6.05
Voltage Regulator 5V	2	2.65	5.30
Electrolytic Capacitor 1uF/50V	2	1.54	3.08
Relay Module 4-channel	2	6.31	12.62
Motor Driver L298N	2	4.90	9.80
Model Ply	2	5.20	10.40
Jumper Wires (M/M)	4	3.70	14.8
Breadboard	1	19.42	19.42
Hose	1	12	12
Nozzle	1	2.21	2.21
Battery 12V	1	19.8	19.8
			Total: 498.32

CHAPTER-6

6.0 Prototype Preparation and Experimental Study

1. Building the first layer of robot chassis and soldering DC motor to each wheel and mounting 12V battery as shown in below figure:

Figure 47 First layer robot chassis building

2. After finishing the first layer of chassis then comes the second layer where all components are mounted and connected to breadboard to test.

Figure 48 Building Second layer of robotic chassis

3. At last, comes the third layer of the chassis on which the tanks along with DC brushless motors and serial manipulator is mounted.

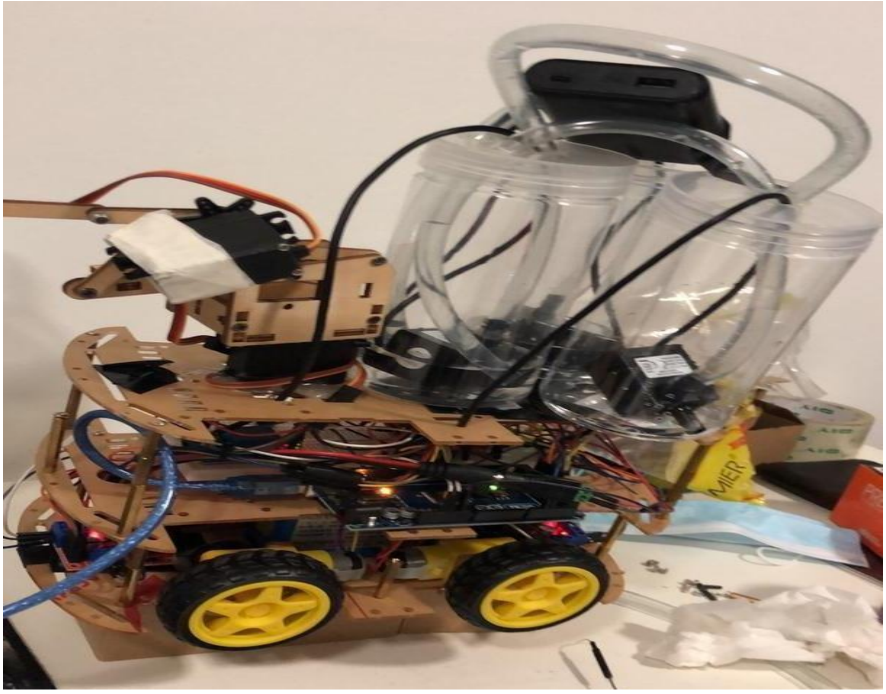

Figure 49 Third layer of robot along with tanks and serial manipulator

4. After the chassis part of the robot is built, we then tested the circuit using breadboard in order to check if the robot is in working condition or to encounter any faulty connection in the circuit.

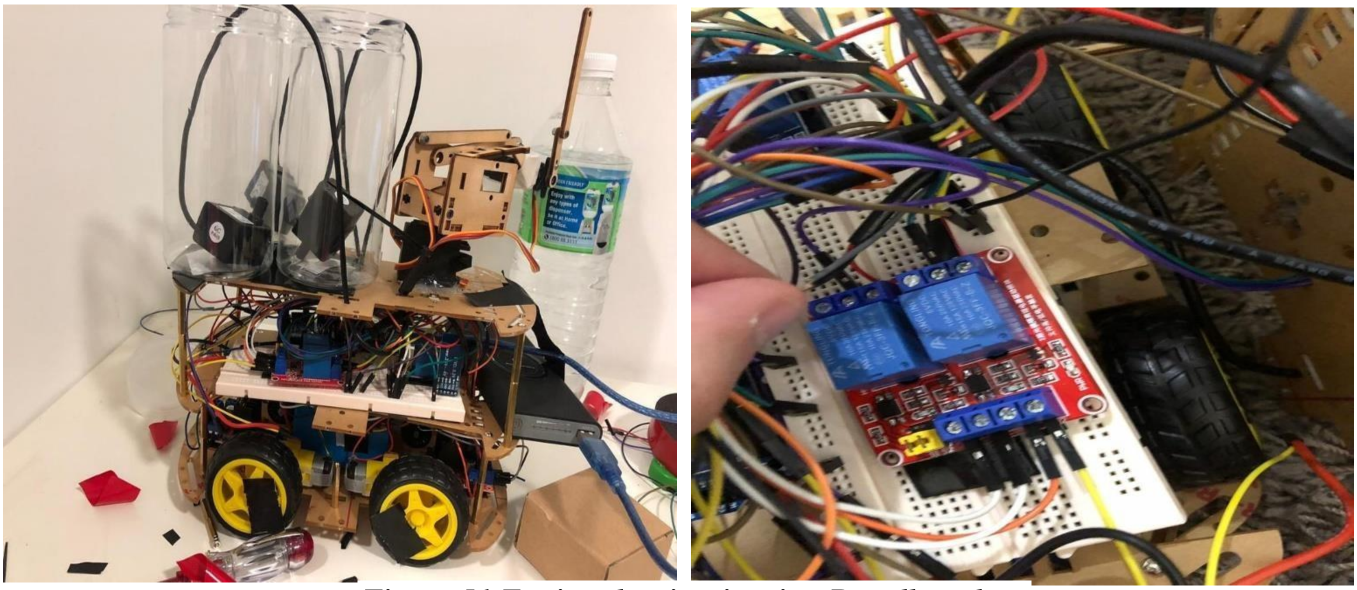

Figure 51 Testing the circuit using Breadboard

5. Once the circuit is tested then comes the testing of manipulator and camera module using the application, we built on MIT APP inventor.

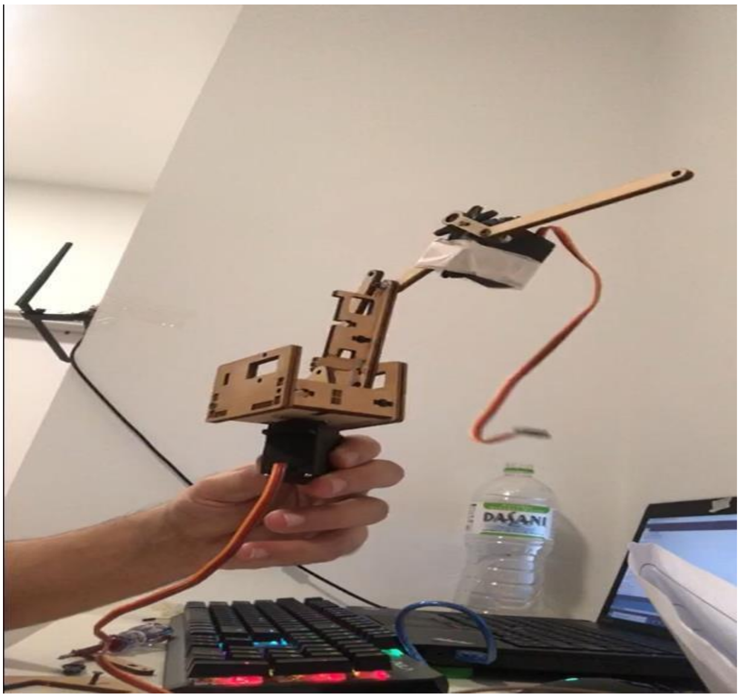

Figure 53 Testing the serial manipulator

6. After testing circuit, camera and manipulator last part comes the casing of the robot which was done using a material called 3mm model ply. The casing is very important as it necessary to protect the components from dust, water and sunlight.

Figure 55 Material used and final look of the robot

Future Implementations

The future development of this herbicide spraying robot will attempt to improve the existing concept and design of the robot, allowing it to execute a wider range of functions and systems, thereby maintaining or improving its overall performance.

There are a number of aspects that can be improved in the system, and they are as follows:

1. Autonomous robot
2. Voice recognition system
3. Chisel blades

Autonomous robot

Robots built and engineered to deal with their surroundings on their own and work for extended periods of time without the assistance of humans are referred to as autonomous robots. Intelligent elements in autonomous robots can assist them in understanding their physical environment and automating parts of their maintenance and navigation that were previously performed by human hands. By adding the right sensors and code, our robot won’t need a person to control it in the future. This way, plantation cites will not need to pay for a person to control the robot.

Voice recognition system

The ability of a machine or programme to receive and interpret dictation, as well as to understand and carry out spoken commands, is referred to as voice recognition. With the emergence of artificial intelligence and intelligent assistants, such as Amazon's Alexa, Apple's Siri, and Microsoft's Cortana, voice recognition has gained popularity and widespread use. By applying this system to our robot, we could just command the robot to spray, stop, turn off, and turn on with just voice commands.

Chisel blades

Chisel blades are capable of cutting through drywall as well as other hard materials such as bricks because of their sharp edges. It is also useful when cutting tree roots since it prevents the roots from becoming entangled in tree branches or little root hairs. It is possible that, after attaching them to the front low side of our robot, they will allow the robot to travel smoothly by cutting or moving anything that gets in its way.

Conclusion

To conclude the project, the students had to think deeply about what features and design could make the herbicide spraying robot suitable for a palm tree cite. After thinking deeply, the group members built a robot that is controlled via an app from their phone. This revolutionary robot can move easily with its four wheels. For spraying the palm trees, the students had the idea of having one sprayer which can move 180 degrees to the left and right as well as be able to move up and down. This great idea can make this robot suitable for any types of plants and trees. The serial manipulator makes sure to get the herbicide sprayed on all the right places that needs to be sprayed. Using the right materials, the students were able to cover all the sides of the robot except the serial manipulator (to make sure it can move and rotate freely). By covering all the sides, this makes the robot immune and safe from any insects or liquids that can get into it. Finally, the students were able to build a herbicide spraying robot that got the job done.

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logs/#:~:text=Chisel%20Blades%3A%20with%20their%20sharp [Accessed 30 Mar. 2022].

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APPENDIX

1. Gantt Chart

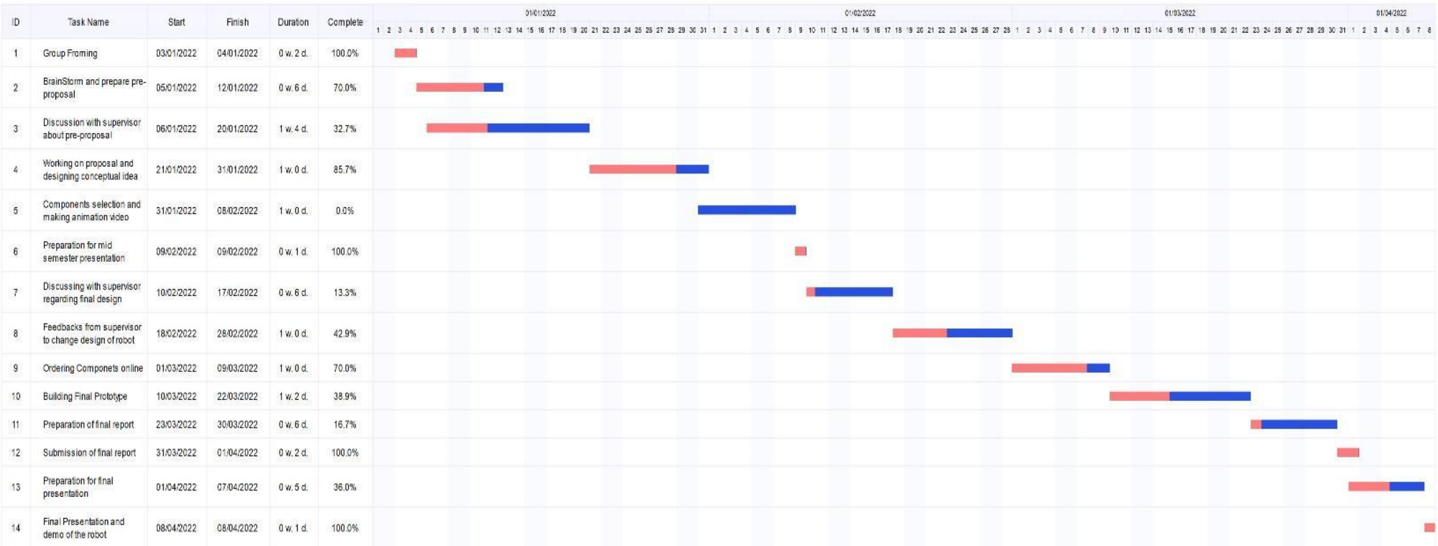

Figure 57 Gantt Chart of capstone Project

2. Animation Video of the robot

Animation Video of the robot.mp4

3. Working of Spraying Robot (Video-1)

Working of the Robot_Video-1.mp4

4. Working of Spraying Robot (Video-2)

Working of the Robot_Video-2.mp4