DEVELOPMENT AND FABRICATION OF AGRICULTURALPEST CONTROL SYSTEM

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CHAPTER 1 INTRODUCTION

1.1 General Introduction

Research is "creative and systematic work undertaken to increase the stock of knowledge". It involves the collection, organization and analysis of information to increase understanding of a topic or issue. Efficient use of pesticides can helpful to control plant pests and diseases to increasethe crop yields. The use of agrochemicals can effectively enhance the quantity and quality of crop;however, it increases the environmental risks in recent years. Pesticide application utilizes the to a significant percentage of the production cost. During chemical plant protectionpractices, over application of pesticide or inefficient spraying equipment may cause serious issueson human healthand the environment. Effective pesticide application is a critical activity during crop production season that requires efficient spraying machinery with proper calibration as well as relevant regulations to reduce off-target spray deposition. Thus, the significant among all the factors which are influencing the degree of off-target spray deposition is the design and application spraying technology Conventional agricultural pesticide application practices havedeveloped a contradiction among the yield enhancement, cost effectiveness and environmental protection. Therefore, pesticides have to be applied using suitable spraying systems to avoid adverse effects on environment as well as human health. Thus, in recent decades, spraying methods and technologieshave been undergoing continuous evolution. Conventional sprayerswere very laborious and requirevery heavy machinery to operating them in the field. They increasethe application amount because of no proper application method for spraying nozzles, crop foliage detection, and weather parameters. advancement in spray application technologies increase crop production and increase pesticide efficiency on weed and insects in the field. Spray loss in the form ofspray drift, weather effects, target detection, and control flow nozzles problem solved by advancedpesticide applicationtechnologies. The time-consuming problem for tank refilling is reduced withultra-low volume sprayers and fine droplet spray nozzles. With time the crop maintaining technology-advance fromweeds and pest, detection to spray application nozzles. The objective of this chapter is to highlight the attachments conceived by both electronics and mechanical components which implies for the working of agricultural spraying machine.

1.2 Research & Development System

The Indian Council of Agricultural Research (ICAR) is the main organization looking after all agricultural research, including agricultural implements and machinery. It coordinates a numberof research projects with centres at different places in the country. Some of the State Governmentshave also facilitated in setting up of research organizations at state level. Each of the state has at least one agricultural university. A research program usually concentrates on the development of equipment suitable to a given farming conditions. The objective is to improve upon the performance of indigenous implements or develop a new implement that can either enhance labourproductivity or appropriately mechanize the operation where a labour or power shortage hinders completing the task in time.

1.2.1 Low Pressure Sprayers

A low-pressure sprayer is an option if you need consistent nozzle pressure on your farm. This typeof agricultural sprayer is available in a variety of configurations, including trailer-mounted, truck-mounted, and trailer-mounted. Depending on the size of the farm that needs spraying as well as thetype of vehicle that you will use, the low-pressure sprayer can hold enough chemicals to help youcomplete the operation quickly. The truck-mounted sprayer can often carry up to 2,500 gallons ofliquid, making it the ideal option for spraying larger farms. Meanwhile, a trailer-mounted sprayer can carry 1,000 gallons of liquid, and a tractor-mounted sprayer, which can hold 150 to 500 gallonsof liquid, should be used for smaller regions. It's also perfect for spraying pesticides or insecticidesin your backyard little garden.

Fig 1.1: Low pressure Sprayer

1.2.2 High Pressure Sprayer

If you need to spray chemicals into thick brush or tall trees, high-pressure sprayers are the way to go. This variant tends to be heavier or more expensive when compared to low-pressure agricultural sprayers. However, some farmers like it since it can spray up to 1,000 psi of liquid each time it passes through the area that has to be sprayed.

Fig 1.2: High pressure Sprayer

1.2.3 Mist Blower

Mist blowers or foggers can be used to disperse liquid insecticides. This agricultural gadgetcan aid in the equal distribution of pesticides. It is equipped with an electric motor that converts chemicals into vapour. It's often used by farmers to treat crop regions and greenhouses that requirea lot of pesticide. However, farmers must ensure that pesticides are sprayed on their crops when the weather is not too windy in order for them to be effective.

Fig 1.3: Mist Blower Sprayer

1.2.4 Air- Carrier Sprayer

This type of agricultural sprayer, also known as mist-blowers or air-blast sprayers, works byspraying insecticides at fast speeds that can reach 80 to 150 miles per spray. When utilising this type of sprayer, the pesticide will get concentrated because it disperses in the air during spraying. As a result, diluting and refilling the sprayer tank only takes a few minutes before you can begin spraying throughout the area.

Fig 1.4: Air Carrier Sprayer

1.3 PRINCIPLE

A simple motor driven robot which can be controlled from a distance can be of great help for the farmers who used to spray the pesticide themselves. At the same time, it takes care of the health of the people who comes in direct contact with the chemicals. Instead of using Artificial Intelligence or Arduino programming for the time being, using simple electronics keeps the cost very low and simple to repair anyone using it. A technology is said to be well used only when it isvery simple to be understood by the most common people. This kind of technology can be used byage category. The transmitter and receiver connections are the vital roles playing in the machine aswell as the other components. A simple transmitter with 6 channel receiver controls over the operations of the sprayer.

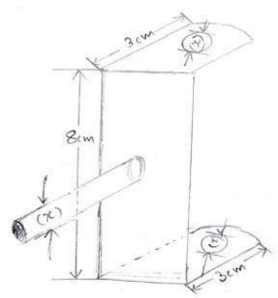

Fig 1.5: Dimensions of king- pin

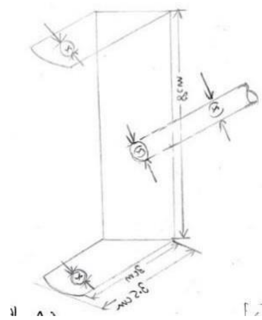

Fig 1.6: Front view of king- pin

CHAPTER 2 LITERATURE SURVEY

2.1 Applications of machine vision in agricultural robot navigation

Many tasks in smart agriculture necessitate the use of agricultural robots that can navigate autonomously. Machine vision (MV) is commonly employed in agricultural robot navigation due to priceless visual information and low hardware costs. The uses of MV in agricultural robot navigation were discussed in this research. The benefits, drawbacks, and roles of various vision sensors and MV algorithms in agricultural robot navigation were first discussed. The state of MV development in agricultural robot navigation was then examined. Finally, the difficulties of MV navigation in agricultural robots were highlighted. To address these issues, this paper looks aheadto the research directions that will be pursued in the future.

2.2 Implementation of drone technology for farm monitoring & pesticidespraying

Every day, more than 200 thousand people are added to the world's population, with the overall population anticipated to reach 9.6 billion by 2050. This will increase food demand, whichcan only be satisfied by increasing crop yields. As a result, agriculture sector modernization has become a pressing demand. There are a number of factors that contribute to low crop output that can be addressed by utilising drone technology in agriculture. This article examines dronetechnology in the agriculture sector during the last decade, as well as their evolution through time.It has been discussed how drones can be used for crop monitoring and pesticide spraying in Precision Agriculture (PA). Work on drone structure, multiple sensor development, and spot area spraying innovation has been presented. Furthermore, the utilisation of Artificial Intelligence (AI)and deep learning for remote agricultural monitoring was considered.

2.3 A Low-Cost Prototype to Automate Agricultural Sprayers

In recent decades, the world's population growth necessitated a significant rise in agricultural production, particularly in food. As a result, farmers are increasingly relying on the use of agrochemicals in their crops to prevent potential losses and ensure productivity.

This widespread use of pesticides not only costs farmers a lot of money, but it also puts theirhealth, the environment, and the safety of the food they eat at danger. Newtechnologies have been developed in this context to improve agricultural spraying by lowering the amount of pesticide applied and dosing its use according to the crop's needs. Precision Agriculture deals with the recognition of its geographical and temporal variability. In the case of pest control, variable-rate sprayers or on/off applications with individual nozzle control can be used. As a result, this paper proposes a low-cost prototypefor automating existing agricultural sprayers as part of a modular solution. Using solenoidvalves, pressure and flow sensors, Arduino boards, and a smartphone, themethod enablesfor individual nozzle opening with on/off control. A data logger feature is also included inthe prototype, which stores nozzle status and sensor values for future analysis and application reports.

2.4 Variable rate sprayer

The canopy's structural properties are an important factor to consider while optimising the spray spraying procedure for tree crops. However, acquiring correct data in a simple, practical, andeffective manner is a critical issue that must be addressed. Following the principles and prior laboratory testing detailed in the related paper Variable rate sprayer, this study details the technicalaspects of a sprayer prototype created for vineyards. Part 1: Design, implementation, and validationof the Orchard prototype. Using an algorithm based on the canopy volume inspired by the tree rowvolume (TRV) model, this prototype may change the sprayed volume application rate according tothe intended shape. Variations in canopy width along the row crop are electronically monitored using many ultrasonic sensors mounted on the sprayer and utilised to adjust the emitted flow rate from the nozzles in real time; the goal is to maintain the sprayed volume per unit canopy volume (L m3) during this operation. Field investigations on Merlot and Cabernet Sauvignon vines (Vitis vinifera) at various crop stages revealed a positive association between applied volume and canopyfeatures. In comparison to the costs of a typical application, the potential pesticide savings were calculated to be 21.9 percent. This conclusion is consistent with the findings of other studies on automated spraying systems.

2.5 Different sensor based intelligent spraying systems in Agriculture

Chemical application of nutrients and pesticides is one of the most crucial, but also one of the most dangerous, processes in agricultural production.

Improving chemical performance, lowering chemical and labour costs, reducing labour dangers, and reducing adverse environmental damage are all goals. Intelligent control systems combined with variable-rate spray sprays can greatly minimise pesticide use and off-target pollution. Pesticides are used more effectively and efficiently with real-time variable-rate sprayingtechnology. Farmers can use the variable-rate spray to administer pesticides only where they are needed, using the right amount dependent on the canopy size, season, and growth phase of the plants. Target detection systems have been created during the last few decades employing complexmethods like laser and vision scanning systems, or, more simply, ultrasound, infrared, and spectrumsystems. Spray that detects targets in real time The systems for detecting the geometric characteristics of tree plants are thoroughly examined. Machine vision and laser scanner systems are the most capable and complementing methods for obtaining three-dimensional images and maps of plants and canopies among these methods. This study provides an overview of various sensor methods for determining canopy structural features and how they are applied to precision spraying. Some of the difficulties and concerns associated with the use of these sensors and technologies are also explored.

2.6. Design and development of a robot for spraying fertilizers and pesticides for agriculture

Agriculture is a very resource-intensive and labour- intensive enterprise. As a result, farmersare increasingly relying on technology and automation to help them deal with the problem. Agricultural robots, on the other hand, are far too intricate, slow, and expensive to be made publiclyavailable. As a result, the agricultural industry continues to lag behind in terms of adopting new technologies. The creation of a low-cost agricultural robot for spraying fertilisers and pesticides inagriculture fields, as well as general crop monitoring, is detailed in this research study. The prototype system includes a two-wheeled robot with a mobile base, a spraying mechanism, a wireless controller for directing the robot's movement, and a camera for monitoring crop health and growth as well as detecting pests in the agriculture field. In this entire project, the major objective is to change the obsolete methods being currently followed in the Indian agriculture systems. The objectives of the project is that the system can move in any terrain.

Tests on the prototype system show that, while the robot's productivity in terms of crop coverage is slightly lower than a human worker, the labour cost savings afforded by the agriculturalrobot prototype are much greater because it operates entirely autonomously, requiring the operatorto only control the robot when placing it at the start of the crop path. Furthermore, the prototype system saves resources and reduces the contamination of subsurface water sources caused by the leeching process, allowing precision agriculture to be achieved. Finally, the prototype system's long battery life ensures that there will be no increase in operating times or reduction in the efficiency of the fertiliser and pesticide spraying process as a result of recharging times when human employees are replaced. To further minimise labour requirements and expenses, future ideas include making the agricultural robot entirely autonomous, employing either a rail- or line- following technology.

2.7 Design and fabrication of an agricultural robot for crop seeding

The creation of a low-cost agricultural robot for crop planting is described in this research study. A mobile base for robot movement and a seeding mechanism attached to the mobile base for crop seeding application make up the prototype system. The seeding mechanism uses the notionof a crank-slider to continually inject seedlings into the ground, while the mobile base includes a four-wheel design to ease movement over difficult terrains. This exhibits a 35 percent improvementin crop seeding efficiency. The battery life test revealed that the robot can operate for up to 4 hourson a single charge. As a result, when human employees are replaced with the prototype system, there will be no increase in operating time or reduction in the efficiency of the crop seeding processowing to recharging times. The robot power supply requires 1.5 hours to recharge. While the prototype system achieved its goal of reducing human interference, labour requirements, and overall operating costs in the field of agriculture for crop seeding, labour costs can be further reduced by making the robot fully autonomous, using either a rail- or line-following system, because an operator is no longer required to manually steer the robot to each seeding path.

2.8 An intelligent spraying robot based on plant bulk volume

Spraying in greenhouses and farmlands is labor- and time-intensive, and it also harms people's health. The best solution is to automate the spraying process using mechanised equipmentand robots.

In this study, spraying is carried out by a robot with four degrees of freedom by computing the plant bulk volume. When it identifies plant stems, the robot stops and gradually opens its manipulator to stop moving along the rows of plants and allow the Kinect v. 1 camera to take deepRGB1 coloured images from different regions. It begins spraying after determining the plant's bulk volume. The outcomes demonstrated the robot's capability to calculate volume effectively. For a plant that is 1.7 m tall, the robot's average operation time for detecting the plant, opening the manipulator, imaging, estimating volume, and spraying liquid based on the estimated volume is 54

s. The robot's estimated detection error is 19 percent, which is quite little. The robot's liquid- spraying quality is not affected at high levels of the plant, according to analysis of liquid-sensitivepapers found nearby. The robot can gauge the height of the plant and maintain the appropriate spraying quality throughout.

CHAPTER 3 METHODOLOGY

3.1 MATERIALS AND EQUIPMENT

Following are the components for the machine.

3.1.1 Mechanical

1) 30mm GI square pipe- 4 meters 2)1mm MS sheet metal- 1*1'5 feet
3) Rubber wheels 15cm diameter- 4
4) Axle for drive wheel, MS- 10mm diameter, 40cm length
5) 60mm diameter sprocket wheels- 2
6) Drive chain
7)3mm MS flat (20 mm width)- 1m for motor bed
8) Reduction gear
9) 10mm MS shaft for motor drive
10) 1 square mm wire- 10m

3.1.2 Electronics

11) 10 MDDS S10 DC Motor Driver
12) MG995 Metal gear servo motor (180^0 rotation)
13) 7.4V 35.5kg.cm 180^0 Metal gear servo motor
14) FS-R9B 2.4G 8CH Receiver

15) SG90 Continuous Rotation 360-degree Servo motor
16) 2200mAh 3S 30C/60C Lithium polymer battery pack (LiPo)
17) Components for electric drives

3.2 DETAILS OF MAIN ELECTRONIC COMPONENTS

3.2.1 10 MDDS10 DC Motor Driver

Smart drive Duo is a smart brush motor driver, support dual channels, 10A continuous currentforeach channel. Building a combat/sumo robot become easy choose motor + wheel, get a proper battery, connect it, choose an RC controller and the operation is done.

This have the specification of MDD10A which is able to drive two brush motor at 10A each, plusadditional smart features of MDS40A. It has the capability to accept RC (Radio Control) signalfor mix mode drive, analog voltage from the potentiometer, PWM from the microcontroller, and even controlled via UART command. the operation modes are configured by the DIP switch on MDDS10. The commonly DIP switch configurations are printed at the back of PCB. MOSFETs are switching at 16KHz for quiet operation. With the onboard temperature sensor, this smart driveris able to limit the output current stage bystage to prevent itself from overheat and burnt! The peakcurrent is 50A for 5 seconds and it will automatically limit the output current. There is an additionof 2x3 header pin, with just 2 RC extension cable, the wiring is done, and it takes only 2 minutes. With MDDS10, there is a series up two SLA battery to power the motor as it supports up to 35V DC input. And only require one power input to operate the motor and driver. 3-cell and 6-cell Lipo-battery are within the operating voltage. It also comes with battery low voltage warning feature.
Several connections together forms up to be attached to the motor controller in which the machinecan work smoothly.

It is clear that the motor controller sets up the entire operations of the device and even two signal connections cam also be converted to three pin signals. The overall performing characteristics and specifications is shown in table 3.1.

Motor controller consist of transistors, resistors and transistors by which the small circuit bears heavy loads.

Fig 3.1: Motor Controller

Table 3.1: Specifications of motor driver

Driver model	MDDS10
Operating Voltage (VDC)	7~35
Peak Current (A)	30
Continuous Current (A)	10
No. of Channels	2
Operating Modes	PWM (Lock-Antiphase and Sign-Magnitude)
Servo Signal	Yes
Over-Current protection	Yes
Thermal protection	Yes
LED Indicator	Yes
Test/Manual Button	Yes
Cooling Fan	No
Arduino Shield	No-can be used with wire Connection
Polarity Protection	NO Dimensions in mm (L×W×H) 67×102×25

3.2.2 6 Channel Receiver

FS-R9B 2.4G 8CH Receiver is very low power consumption and high receiving sensitivity receiver. With extreme rigorous testing by engineers and studying the markets for years, this is now considered to be one of the best systems available in the market. Its 2.4GHz is the standard ofnew generation radio system because it has a lot of advantages. Operating at 2.4 GHz puts the radiocontrol out of the frequency range of any 'noise' generated bythe other electronic components on your devices – such as the brushless motor, electronic speed controller, Servos and any metal-to- metal noise – eliminating interference and glitching that can affect traditional frequency system.

Fig 3.2: 6CH Receiver

Table 3.2 Specifications of 6CH receiver Operating Frequency 2.4G

Operating Power	5V DC (4 x 1.5V AA)
Weight (gm)	25
Antenna Length	26mm
Dimensions in mm (L×W×H)	52 x 33 x 15
Certificate	CE, FCC, RoHS
UPC	602731641097
Number of Channel	8
Modulation Type	2.4G
Modulation	GFSK

3.2.3 35.5Kg.cm 180 Metal Gear Servo Motor

The construction and testing of this Servo with Steel gear material inside gears and a tight sturdy plastic case which makes them water and dust resistant. This is a must feature required in Boats, and RC Monster Trucks, etc. It equips a 3-wire JR servo plug which is compatible with Futaba connectors too. The **7.4V 35.5kg.cm 180° Metal Gear Digital Servo Motor** with any servocode, library, and hardware. It rotates approximately 120-degree, 60 degrees in each direction. Thismotor package comes with a selection of hardware and arms.

Wire Description:

- RED – Positive
- Brown – Negative
- Orange – Signal

Fig 3.3: Servo motor

Table 3.3 Specifications Of servo motorOperating Voltage (VDC) 4.0 ~ 8.4

No load Speed (RPM)	"42@6.0V (0.185sec/60°)52@ 7.2V (0.151sec/60°)
Stall Torque (Kg-Cm)	28.8@6.0V35.5@7.4
Operating Temperature Range (°C)	-20 to 60Maximum Operating Current (A)
	3.8
Dead Band Width (µs)	≤4 Gear Material Steel
Rotational Degree	180° Continuous Rotation
Shaft Type	6mm (25T-M3)
Connector	JR
Command signal	PWM
Weight (gm)	70

3.2.4 MG995 Metal Gear Servo Motor

It equips very good quality DC motor and a thicker connection cable than other servo motorsthatwe sell, hence we are selling it as a Good Quality Servo Motor**.** It has metal gears which makesitrobust and reliable motors. These MG995 Servo Motors are the high-speed servo motors with themighty torque of 13 kg/cm. They are compatible with all the applications that use the genuine MG995 Servo Motor because of their same size, comparable quality, and optimized performance.They equip good quality ballbearings to make operation smooth and safe. The MG995 High-SpeedDigital Servo Motor rotates 90° in each direction making it 180° servo motor. It is a digital servo motor which receives and processes PWM signal faster and better. It equips sophisticated internalcircuitry that provides good torque, holding power, and faster updatesin response to external forces,fig 3.4 shows about the assembling of 2 servo motors. They are packed within a tight sturdy plasticcase which makes them water and dust resistant whichis a very useful feature in RC planes, Boats, and RC Monster Trucks etc. It equips 3-wire JR servoplug which is compatible with Futaba connectors.

Fig 3.4: Assembled servo motor

3.2.5 2200mAh 3S 30C/60C LiPo Battery

Heavy-duty discharge leads are provided for the Orange 3S 30C/60C 2200mAh battery Pack (LiPo), primarily to reduce resistance and support high current loads. RC vehicles and aerobatic flight both put orange batteries to the test. Each set comes with JST-XH style balance connectors and connectors with a gold coating. Additionally, IR match cells are used in the assembly of all Orange Lithium Polymer battery packs to offer great reliability.

Safety Precautions:

1. Avoid over-charging or over-discharging the batteries.
2. Do n0t put it beside the high-temperature condition.
3. Don't throw it into the fire or Water

Table 3.5 Spec. of li-ion Battery pack

Model No.	ORANGE 2200mAh/4S-40C
Capacity	2200
Weight (gm)	34
Output Voltage (VDC)	14.8
Charge rate (C)	1~3
Discharge Plug	XT-60
Balance Plug	JST-XH
Max. Burst Discharge	80C
Max. Charge Rate	5C
Max. Continuous charge	40C

3.2.6 DC Water Pump

This is 550 Diaphragm Pump 12V Water Pump for Water Spray Fish Tank Reflux Pump. DC 12V3.5L/Min Micro 550 Diaphragm Water Pump Watering Spray Aquarium Return Pump for HomeGarden. The configuration of the bath is according to the saving configuration: 12V2A powersupply, busconnector, 4m 7 x 10 silicone tube, a 550-water pump, as for the shower nozzle, you can find a plastic bag, a good quality plastic bag or big cola bottle, The water intake and the amountof watercan be equivalent.

Feature:

1. Watering configuration: much the same, additional sprinklers and timers are required
2. 2V DC reflux diaphragm pump 550, the price is the price of a pump, without otheraccessories
3. Voltage: 12V, current: at least 2A, measured 1A is not able to bring
4. Suction: 3 meters or so, preferably 2 meters (no problem if the vertical height is 1.5 meters).
5. Head: 4-5 meters (head is not shot)
6. Highest temperature resistance 55°
7. Connect the mouth: the same as the outer diameter of the inlet and outlet, about 8.5mm,thenconnect the inner diameter of 7mm silicone tube tightly

Fig 3.5 12V water pump

3.3 WORKING

3.3.1 Propulsion Mechanism

The rear axle is coupled with the help of chain and sprocket. The rear live axle held a sprocket and is directly connected to the sprocket of wiper motor with the help of chain links. The rear live axledoes not have any differential and it acts as a locked differential, thereby contributing to a torquingand gripping maneuver. The 12V wiper motor is accurately controlled using smart-drive duo motorcontroller which is actively communicating with the RC. As the part of the mobility, all the machinecomprises of rubber wheels, axle for wheel drive, sprocket wheels, drive chain, reduction gear, 30mm GI square pipe, 1mm MS sheet metal, 3mm MS flat (20 mm width), 10mm MS shaft and 1 square mm wire.

3.3.2 Steering Mechanism;

The steering mechanism used here is simple go-kart steering mechanism, because as the name saysit's very easy and reliable and simple to understand. This automobile has to undergo only small turning radiuses thus using this particular steering mechanism is more than enough. A high torqueto be exact 35kg servo motor is used for the steering mechanism. 'C' shaped king pin are used forholding the steering wheels and these king-pin are connected to the servo motor with the help of steering links. The high torque servo motor can accurately position the steering wheels same as desired by the user. The driving power is manipulated by the rear wheels, in which 40cm length axle is connected to the both the rear wheels with 10mm diameter. A 60 mm diameter sprocket is welded at the center of the rear axle, so that sprocket rotates when the rear axle shaft rotates. The sprocket is connected to another sprocket in the wiper motor by drive chain. So, the power transmitted by the wiper motor is transferred through sprocket –chain-sprocket link, to the rear axle. Such that wheel has high torque which is generated from the wiper motor. The king pin inclination for the front isn't considering as of the high torque in rear axle as shown in fig 3.6.

Castor and Camber angles;

- Camber angle is not considered in this situation
- The automobile has a very limited speed of range thus the camber and toe in, toe out and king pin inclination has not considered here.
- Castor is desired to be positioned as negative castor for more easier steering, or effortless steering.The steering is done by servo so minimalistic effort steering is preferred.

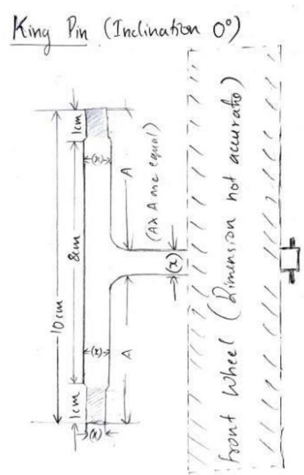

Fig 3.6 design for front steering

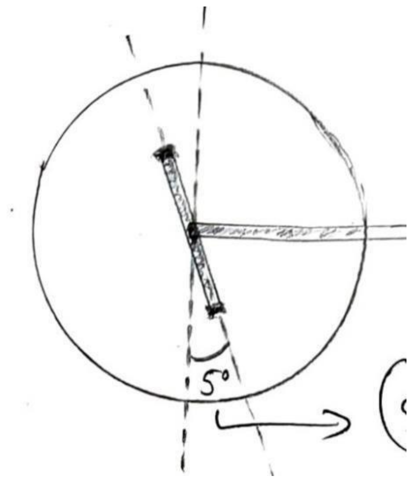

Fig 3.7 Negative 5º castor angle

3.3.3 Storage

The storage tanks are made from PVC pipe and 4 end caps which have 5 inch dia and 40cmlength. The storage tanks are located at the both the rear and front section of the pest control system.Each of the tank constitutes of 7.5L leaving the tank size to be 15L. Both the tanks are fixed at theboth ends. Each tank has a opening for filling the pesticide and the both tanks are connected to each other with half inch pipe for the better pressure and which is connected to the T junction. TheT junction is connected to the water pump.

3.3.4 Electrical and Electronics mechanism

There are several electronic components in the pest control system, all the operations are controlled by the 10 MDDS10 DC motor driver. Motor driver acts as the interface between the motors and controlling unit. Motor driver covert step and direction input from the controller to currents and voltages compatible with the motor. Function of motor driver is to take a low currentcontrol signal and then turn it into a higher current signal that can drive a motor. Smart drive helpsto limits the heat produced due to overload caused by motor. The water pump and wiper motor used in pest control system is 2 pin connection, such that it cannot directly connect into the receiver.So, pest control system used motor driver as a interface between them. 12volt pumps cannot be connected directly to receiver. Hence, the pumps are connected to the motor driver and resulting of a 5.6V. Then, the above are connected towards the receiver as a 3-point pin.

- 7.4 V 35.5 kg.cm Metal Gear Servo Motor

  The steering mechanism of pest control system is according to the simple go kart steering system. Hence, we use metal geared servo motor for rotating the wheel by this mechanism. The geared servo motor helps to carry upto 35.5 kg, So the geared motor will be able to carry the weightacting upon the pesticide control system. It is directly connected to the 8CH receiver.

- 12V Wiper motor

  12 V wiper motor offers high torque in a small package, in which back axle of pest control system is powered by wiper motor. And it is required to go into different terrains in a field, So the wiper motor helps to overcome the terrains.

- DC Water pump

  The inlet port of 12V DC water pump is directly connected to the 15 L water storage and theoutlet port of water pump is connected to the pipe that joints nozzle. DC water pump produces highpressure, So the pest control system can spray the pests up to 2.5 meter. Since large farms can be easily sprayed by pest control system.

- MG995 Metal Gear servo motor (180º rotation)

  Pan and tilt mechanism involve a motion on a motion design in which one motor controls one axis of motion while a second motor moves the first motor. The nozzle from the water pump is connected to the first servo motor. It is directly connected to the receiver.

- 8-CH RECEIVER

  Receiver takes the input of all the operation of pest control system. Servo motors are directly connected into the receiver and, wiper motor and water pump are connected through motor driver.

- Transmitter

  Finally, the overall controls are performed by the transmitter and is known to be the hand ofpesticide sprayer. Movements, articulations, steering, source of power of pressure of the water arriving at the nozzle is all being controlled by the transmitter. Mainly the device which uses the 6-channel transmission is a great help to the system.

Main components comprised of electronic equipment and it helps in the overall automobileand mechanical features of the project. Hence, as a mechanical project it completes all it's workingwith the hand-in-hand operations of the sprayer.

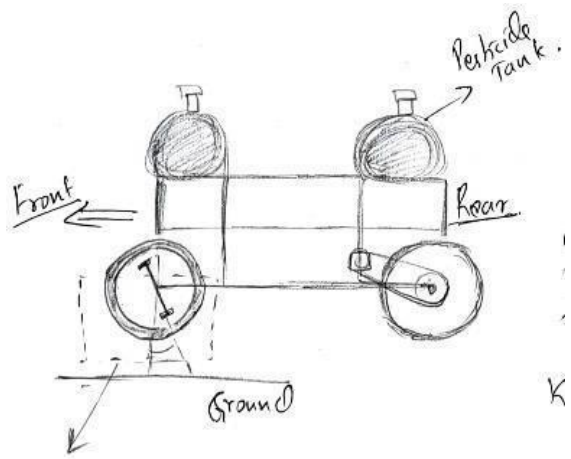

Fig 3.8: Simple Design of Sprayer

3.3 Budget and Overall Analysis

The overall design appears to be consistent for a duration of period. Tyres can last years andas the tank is made of plastic, it can be proclaimed as a non-rusty material. The gears, chain sprockets and mechanical equipment which are used for the sprayer can also last for a period of months. Apply lubricants frequently as for the duration of these materials.

The overall cost was estimated as around twenty thousand and some of the items were returned or replaced under failures of different circumstances. The overall budget was covered by the teammates. Time required to complete the project was around **3 months**

OVERALL BUDGET OF THE SYSTEM

Item	Price
4 Wheels	nil (scrap)
Steel bars	nil (scrap)
Plastic pipe (dia-45mm)	nil (scrap)
Steel pipes	nil (scrap)
Motor Driver	Rs. 4,025.00
MG995 Servo motor	Rs. 819.97
Servo mount brackets	Rs. 198.03
Data line cable access wiring connector	Rs. 502.00
OT5330M 35.5Kg.cm servo motor	Rs. 1,790.92

XT60 connectors	Rs. 304.94
8CH receiver	Rs. 1,155.79
Heat Shrink Sleeve	Rs. 73.89
2200mAh LiPo battery pack	Rs. 1,549.00
Voltage tester	Rs. 125.00
12V water pump	Rs. 650.00
Mist type Nozzle	Rs. 149.00
Orange pipe	Rs. 99.00
Wiper motor	Rs. 550.00
Transmitter	Rs. 3,649.00
Spray paint	Rs. 180.00
Black paint	Rs. 50
TOTAL	Rs. 16,194.27

Failed/ Returned Items

43A H-Bridge (Returned)	Rs. 699.00
5G90 micro servo motor (fail)	Rs. 189.00
Continuous rotation servo motor (Returned)	Rs. 194.12
30A Brushed ESC No brake (2) (Fail)	Rs. 1,033.34
TOTAL	Rs. 2,115.46

CHAPTER 4 RESULTS AND DISCUSSION

4.1 Spraying

In order to show that the robotic pesticide sprayer helps to reduce labour requirementsand associated expenses for fertiliser and pesticide spraying, when compared to a human worker usinga backpack sprayer, the robot covered more plants in 10 minutes. To lower overall testing expenses, the liquid fertilizer and insecticide were replaced with water for this test.

As per our tests, the autonomous mode of the robotic pesticide sprayer is allowed it tospray liquid fertilizers and pesticides on 40 plants per minute, compared to 30 plants per minute for a human worker using a backpack sprayer. As a result, the robot covered 200 plants in 5 minutes, comparedto 150 plants by the human worker.

While the robot's crop coverage productivity is marginally higher than that of a humanworker, the agricultural robot's labor cost savings are substantially greater because it operates totallyautonomously and just requires the operator's control.

As a result, the cost of hiring an extra worker to spray fertilizer and pesticides can becompletely removed. This is especially true in large farms when the procedure necessitatesthe participation of several personnel. Using several agricultural robots for this procedure saves money in the long run because the robots only need to be purchased once and maintained on a regular basis, rather than paying workers by the hour.

The robotic pesticide sprayer, sprays uniformly so that all the plants will get equal amount of pesticides each, however a human worker using a backpack sprayer may not haveuniformity as it.Here the sprayer is set in a way that there will be no excess pesticide will besprayer, so that pesticides will not get wasted and it also helps to control leeching.

Fig 4.1 Rear view of machine

4.2 Battery Life Test

A battery life test was conducted on the agricultural robot prototype to ensure that it is able to perform all the required functions including pesticide spraying as well as the controlling of the pesticide sprayer. Robotics pesticide sprayer was created to replace humanworkers in order to cut labor requirements and costs, a long battery life is required so that the robot does not need to be recharged as frequently.

The battery life test for the robot base was conducted by running the agricultural robotprototype continuously over the length of the first crop. During this time, the spraying mechanism was activated intermittently to simulate a real-world usage. Once the robot reached the end point of thefirst crop path, the operator stops spraying it and placed it in the starting of the second crop usingRC controller. when the operator controls again the robot starts to spray the pesticides in the secondcrop till its end.

Based on the battery life test, it was determined that the robot base takes 1.5 h to completely depletefrom a full battery level, the battery backup was just compromising, thus it has sprayed efficiently. In order to increase the battery time, we can use series of batteriesto use the robot uninterruptedly. The recharging duration for the robotic pesticide sprayer isalmost 1.5 hours, whena single battery is connected. There will not be an increase in the operation times and reduction in the efficiency of the pesticide spraying process due to the recharging times when human workers are replaced with the robotic system. Battery poweraffects in the spraying capacity of nozzle. When charge is low, we can experience a corresponding outrage of pesticide from the nozzle.

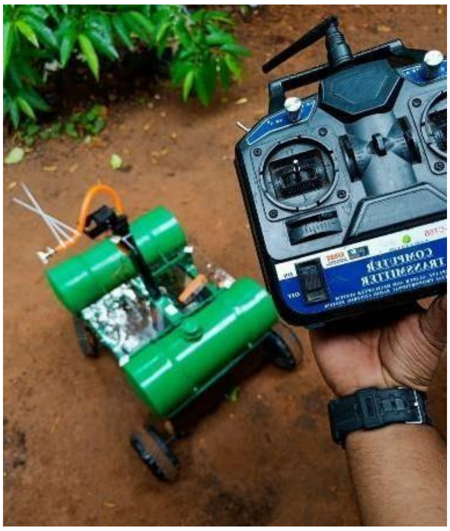

Fig 4.2 Sprayer with RC

CHAPTER 5 CONCLUSION

The goal of this study was to create a healthy pesticide sprayer which is controlled bya remote. Keeping cost in mind, the machine was made budget friendly too. The robotic system comprises of a four-wheeled robot with a base, tank, spraying mechanism, and a wireless controller for controlling the robot's movement. Tests on the robotic pesticide sprayer revealed that it could behave as expected in real-world situations.The spray test demonstrates that robotic sprayer can spray pesticides on 40 plants per minute as opposed tothe human worker's 30 plants per minute with a sprayer in a backpack.

While the robot's crop coverage productivity is slightly lower than that of a human worker, the agricultural robotic pesticide sprayer labour cost savings are substantially greaterbecause it operates totally by a single operator.

Furthermore, the agricultural robot pesticide targets and sprays the liquid pesticide only on the plants, Unlike human workers who use a backpack sprayer to saturate the entire crop routewith pesticide. Thus, the robotic sprayer is able to not only reduce the labour requirements and costs, but also result in greater resource savings and reduction of thecontamination in undergroundwater sources due to leeching process.

Pan and tilt articulation was also a concern at the initial stage, which was accomplishedby two servos adjoined and connected. This helps in the four directional movement of the semi-automatic system.

Based on the battery life test, it was determined that the robot base takes 1.5 h to completely deplete from a full battery level, the battery backup was just compromising, thusit has sprayed efficiently. In order to increase the battery time, we can use series of batteries to use the robot uninterruptedly. The recharging duration for the robotic pesticide sprayer isalmost 1.5 hours, whena single battery is connected. There will not be an increase in the operation times and reduction inthe efficiency of the pesticide spraying process due to the recharging times when human workers are replaced with the robotic system.

The distance calculated for the sprayer was about 2m and the height which it reachesis about 7ft. This was a remarkable achievement that the machine can cover a vast area in less time.

Deep involved knowledge of fabricating a semi-automatic pesticide sprayer was provided and the well establishment too results in the better knowledge of mechatronics.

5.1 Scope for future work

Significance of the research: The original idea behind the research was to develop an efficient But budget friendly agricultural pesticide sprayer. The system well definitely works not only as pesticide sprayer, but also can be used as a muli-purposed system. The equipment can be used to throw fire, watering the plants, etc. The inspiration was drawn from the need of time and man-power for spraying, which is universally considered as the big asset to be simplified by developing an easy operated system which is remote controlledfor spraying.

Limitations of the Study: The limitations can be briefly stated as;

- Wheel system of the sprayer. The tyre system limits the type of terrain which is used. TheAddition of track rail system was initially suggested, but the high cost was a concern and the Idea was dropped.
- The availability of knowing the tank capacity while usage. This lacks slightly in the efficientUse of the sprayer.
- Spraying mechanism is provided only the left-hand side of the automobile with around 180degree pan. Hence, the automobile has to be turned around for the right-hand side operations.
- There is only rear wheel drive provided which decreases the traction of the automobilecompared to track drive automobile.

Suggestions/Future works: Suggestions that can be added to the existing project;

- Addition of track rail system will provide an enhanced routing on different levels of terrain.
- Tank Level Indicator (TLI) can be implemented for the display of the capacity of tank.
- A complete rotating pan servo action is required for the full degree spraying from the nozzle.
- Front axle drive can also be added to increase the traction of the automobile.

REFERENCES

[1] Dhiraj N kumbhare, vihalsingh, prashilewaghmare, Altaf Ansari, Vikas Tiwari andProf.R D. Gorle, (2016), *Fabrication of Automatic Pesticides Spraying Machine.*

[2] AfifShazwan Abdul gafoor, Sami Salama Hussenhajjaj, Kisheen Rao Gsangaya, Mohamed Thariq Hameed sultan, Mohd Faizy Mail, Lee Seng Hua, (2020), Design andDevelopment of a Robot for Spraying fertilizers and pesticides for agriculture.

[3] A.BouzarEssaidi, O. Lakhal, V. Coelen, A. Belarouci, M. Haddad, R. Merzouki.(2020), Trajectory Planning for Autonomous Wheeled Mobile Robots with Trailer.

[4] Fabio P. Terra, Gabrielle R. A. da Rosa, Jardel J. P. Prado, Paulo L. J. Drews-Jr. (2020);A low-cost prototype to automate Agricultural sprayers. IFAC Papersonline 53-2(2020)15835- 15840

[5] HojatHejazipoor, Jafar Massah, MohsenSoryani, Keyvan Asefpour Vakilian, Gholamreza Chegini (Jan 2021), "An intelligent spraying robot based on plant bulkvolume"

[6] Aishwarya. B. V, Archana.G and C. Umayal, "Agriculture robotic vehicle based pesticide sprayer with efficiency optimization," 2015 IEEE Technological Innovation inICT for Agriculture and Rural Development (TIAR), Chennai, 2015, pp. 59-65.

[7] A.Linz, D Brunner, Fehrmann, T. Herlitzius, R .Keicher, A. Ruckelshausen, H.P Schwarz, "Modelling environment for an electrical driven selective sprayer robot inorchards." Available online 12 April 2021 ,Version of record 12 April 2021.

[8] Victor J. Rincon, Macro Grella, Paulo Marucco, Leandro Eloi Alcatrao , Julian Sanchez Hermosilla , Paolo Balsari, "Spray performance assessment of a remote – controlled vehicle prototype foe pesticide application in greenhouse tomato crops." Science of thetotal environment volume 726,15 july 2020,138509.

[9] J.P Vasconez, G.A Kantor, "Human-robot interaction in agriculture: survey and current challenges". Biosyst. Eng.179(2019)35-48.

[10] A. Ullah, J. Ahmad, K. Muhammed, M.Y. Lee, "A survey on precision agriculture: technologies and challenges." International conference on next generation computing, Kaohsiung, Taiwan ,21-24 December 2017, pp.1-3.

[10] S. Sakai, K. Osuka, M. Umeda, "global performance for agricultural robots". International conference on intelligent robots and systems, Sendai, Japan,September 28– October 2, 2004, pp. 461-466,2004.

[11] X. Gao,"*Review of wheeled mobile robots,navigation problems and applicationprospects in agriculture".* IEEE Access 6 (2018)49248 -49268.

[12] J.Erbaugh,B.Hansen ,*"Toward sustainable agriculture in the topics ."*World Dev 121(2019)158-162.

[13] D.Mcgowan, C.Vasilakis,*"Reap what you sow: agricultural technology, urbanizationand structural change".* Res. Policy 48(9) (2019) 103794.

[14] S. Boobalan, M. Jevvabharathi, R.Sathish, *"Highly precise autonomous operatedagricultural robotic machine to fertilize plants selectively controlled by using PLC."* IJAREEIE (2019)8727-8733.

[15] B.S .Shivaprasad ,M.N Ravishankara , B.N Shoba ,*"Design and implementation ofseeding and fertilizing agricultural robot".* I-JAIEM 3(2014)251-255.

[16] C.Gao, Y. Su, H. Ma, *"Agricultural robot path tracking based on predictable path".*2010 international conference on networking and digital society, Wenzhou, china,30 may 2010, pp.

[17] Foque, D. Nuyttens, *"Effects of air support and spray angle on coarse droplets spraysin ivy plot plants".* ASABE 54(2),409-416 ,2011 a.

[18] Garcera,C., Fonte, A.,Molto,E.,Chueca,P.,*"Sustainable use of pesticide applications incitrus: a support tool for volume rate adjustment".* Int. J.Environ.Res. Public health 14,715.

[19] Gaecera C., Molto, E., Chueca, P., *"Spray pesticide application in mediterranean citrusorchard: canopy deposition and off target losses".* Sci. Total Environ .599-600,1344 1362,2017 b.

[20] Gil,E.,Escola,A.,Rosell,J.R.,Planes ,S.,Val,*"Variable rate application of plant protection products in vineyard using ultrasonic sensors"*. Crop Prot. 26,1287 1297,2007.

[21] Pergher ,G.,*"Recovery rate of tracer dyes used for spray deposit assessment ."*TransASAE 44(4),787-794,2001.

[22] Popp,J.,Peto,K.,Nagy,J.,*"Pesticide productivity and food security .A review . A AgronA Sustain."*Dev .33,243-255,2013.

[23] Van Lenteren ,J.C.,*"A greenhouse without pesticide :fact or fantacy ?cropprot."*19,375-384.

[24] R. Sonnino, C.Tegoni, A.Cunto, *"The challenge of systemic food change :insights fromCities".* Cities 85(2019)212 -226.

[25] A.Dinar,A.Tieu ,H.Huynh,*"Water scarcity impacts on global food production."*GlobFood sec .23 (2019)212-226.

[26] J.Erbaugh,B.Hansen ,*"Toward sustainable agriculture in the topics ."*World Dev 121(2019)158-162.

[27] C.Gao,Y.Su,H.Ma,*"Agricultural robot path tracking based on predictable path."*2010 international conference on networking and digital society, Wenzhou, China,30 May 2010, pp.519-521.

[28] Mansad Aboobacker, Aswin Manoj Kumar, Ajay Mohanraj, Tenzin Yarphael, (2019), *Robotic Pesticide Sprayer. (ISBN 978-81-939343-0-2).*