Design & Development of Solar Assisted Autonomous Weed Killing Robot

A DISSERTATION

Submitted in partial fulfilment of the

Requirements for the award of the degree

of

BACHELOR OF TECHNOLOGY

in

MECHANICAL ENGINEERING

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CANDIDATE'S DECLARATION

We hereby declare that the work presented in this dissertation entitled "**Design & Development of Solar Assisted Autonomous Weed Killing Robot**", submitted in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology** in **Mechanical Engineering** is an authentic record of work done by my/our own efforts with suitable acknowledgement to all references.

This work has been carried out by us under the supervision of **Dr. Roshan Udaram Patil**, Department of Mechanical Engineering, IIT Jammu during August 2022 to December 2022. We have not submitted the matter embodied in this report for the award of any other degree or diploma to any other institute or university.

Date: 10/12/2022

Place: Indian Institute of Technology Jammu

Dhiraj Kiran Pimparkar

Nishtha Gupta

Shivank Kapila

Vansh Rai Saini

CERTIFICATE

This is to certify that the above statement made by the candidate is true, to the best of our knowledge and belief.

Dr. Roshan Udaram Patil

(Signature)

Mechanical Engineering, IIT Jammu.

ACKNOWLEDGEMENT

We would like to express our sincere thanks, immense pleasure and gratitude to Dr. Roshan Udaram Patil for his guidance & supervision throughout the entirety of this project. We would also like to extend our gratitude towards the Evaluation Committee for their valuable inputs which help shape the final product.

We are very thankful to our parents & all of our friends for their never-ending encouragement in bringing out this dissertation report to the form as it is now.

Date : 10/12/2022

Place: Indian Institute of Technology Jammu

Dhiraj Kiran Pimparkar

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ABSTRACT

Research and development of autonomous mobile robotic solutions that can perform several active agricultural tasks like sowing, harvesting, pruning etc. have been growing. Robots are now used for a variety of tasks such as planting, weed killing, harvesting, and others. For performing these tasks, detection of plants and weeds plays a vital role.

In this dissertation, we have developed a Solar Assisted Weed Killing Robot which is designed to detect weeds (up to 12 cm in height) in a cotton field and remove them. Since different soils have different water holding capacities, the design considerations for the robot have been estimated in such a way so as to successfully traverse in marshy terrains of black cotton soil.

In the experimental section, a Raspberry Pi 4B and an Arduino Uno have been employed to garner control of the custom 3-D printed wheels with spikes, rotor blade and an external camera for video input feed. A Computer-Vision model using ResNet 50 architecture has been deployed on Raspberry Pi, which is tasked with detecting and identifying if a cotton plant is present in front of the robot or not via the video feed. The output from the computer vision model dictates the traversal and commands the robot by prompting it to move forward, and take turns. The weed uprooting mechanism is also characterized by the prompt received from the model to lower the rotatory blade to perform the action of weed removal.

The present endeavor encompasses successful building of a prototype with all the mechanisms in optimal working condition along with successful segregation of cotton and weed plants.

CONTENTS

Nomenclature

RR	Rolling Resistance acting on the Robot
AR	Aerodynamic Resistance acting on the Robot
GR	Grade Resistance acting on the Robot
P	Density of air
A	Frontal Area of the Robot
V	Velocity of the Robot
Cd	Coefficient of Drag
α	Angle of slope

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1.1 INTRODUCTION

Weed control has been a long-standing issue in agriculture for over a century. The uniform spraying of herbicides has proved its efficiency in weed control, but it has also introduced environmental pollution, human health concerns, and herbicide resistance fears. Because of the negative consequences, governments and farmers are attempting to limit herbicide use in agricultural activity. Precision farming offers a solution to this problem by utilising weeding mechanisms to address individual plants or small weed clusters. Human-oriented precision weeding machinery, on the other hand, typically necessitates inefficient and labor-intensive human resources, which cannot justify the economic benefits of herbicide savings.

Because of its considerable potential to improve weeding efficiency while lowering environmental and economic costs, automated weed control, including weed detection and removal, has acquired substantial popularity in the precision farming community in recent years. Many robotic weed control systems have been proposed, with a focus on single tactics such as selective chemical spraying, mechanical weeding, flaming, and electrical discharge. To detect weeds, smart weeding machines rely on the performance of the machine vision system. However, environmental uncertainties such as illumination and colour variation in leaves or soil impair the performance of the machine vision system, limiting the weed control accuracy. Significant progress has been made toward learning-based weed detection technologies as artificial intelligence has flourished. Such systems, which employ a Convolutional Neural Network (CNN), have been shown to produce more reliable crop/weed detection findings.

Within the scope of our project, we have presented the design, implementation and evaluation of a compact automated weed killing robot suited to traverse in marshy and moisture laden terrains, primarily cotton fields to uproot weeds which hinder growth of young cotton saplings. Cotton was chosen as part of the study as it constitutes a majority chunk of the agricultural economy and as of now, is extremely expensive due its labour-intensive nature of weed uprooting in thick black soil. By targeting this niche and automating it, we aim to innovate a sustainable solution for cotton farming industry.

1.2 LITERATURE REVIEW

After conducting a detailed literature survey to understand the developmentds made in this domain we came across a multilayer design framework for intelligent machines and field robots consisting of four technology layers. This can be depicted in Figure 1.2.1. They tend to stack on each other beginning from the machine architecture layer containing both the hardware and software architecture required for the robot's functioning. Next comes the machine awareness layer consisting of the perception localization, and monitoring technology required by the robot to be aware of its own systems and environment.

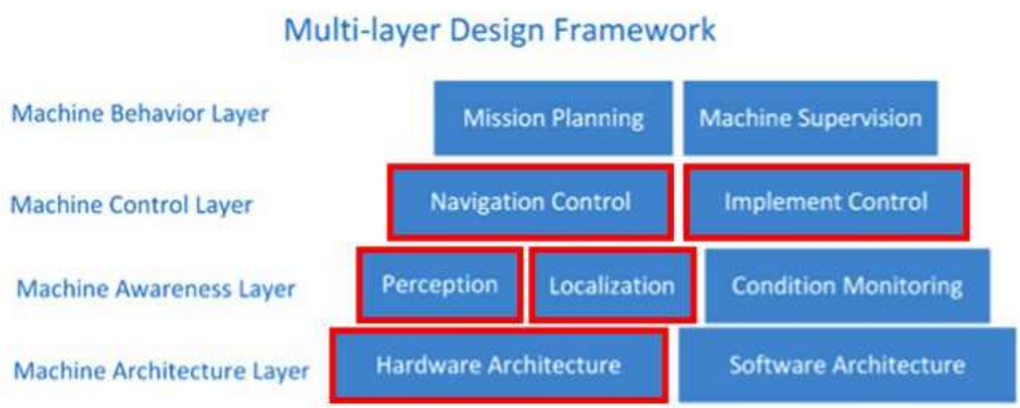


Figure 1.2.1: Multilayer design framework for intelligent agricultural machines & field robots

Robots interact with their surroundings, necessitating the inclusion of actuator control systems in the machine control layer. Machine planning and supervision technologies connected with the top machine behaviour layer are essential for autonomy and the ability to achieve goals under uncertainty. According to a review of the literature, robotic weeder technologies have typically included technology at the lower three layers such as hardware architecture, perception, localization and navigation, and implement control. The machine behaviour layer, as well as condition monitoring technology, are mainly lacking. As a result, it is impossible to conclude, without diminishing the technological effort published in the literature, that we have robotic weeding technology today. However, developments in the field are accelerating.

All the robotic weeders documented in the literature are not truly robotic weeders, but are ‘essentially self-guiding vehicles carrying weeding tools.’ It is based on the fact that the practical application of mechanical weeding instruments is complicated. This complexity is due to various aspects, including soil qualities that change depending on soil type and environmental conditions such as soil moisture content, variability in weed plants and crop plants, and the reaction of these plants to mechanical weeding instruments.

Several key factors must be met for agricultural robots to effectively control weeds. Problems must be resolved. First, weed and crop plants need to be accurately spotted in a field of crops. Plant location, classification of weed and crop plants, and plant detection must all be part of the perceptual system. Second, the weed control strategies that best suit the cultural norms of the production system must be considered while developing the weed control mechanisms. Third, the mechanism must be directed to function near the locations of the weed plants and far from the crop plants depending on the data from the perception system. Fourth, a weeding system must incorporate each of these technologies. We focused on developing of a robotic weeder including a perception system and path traversal algortihm specifically targeted around cotton plants. The adaptability of the system still stands with the flexibility factor primarily dependent upon the dataset proivded for training and validation purposes. However, the design is precisely designed to operate in fields where line-sowing is a common practice.

1.3 PROBLEM STATEMENT

The Indian economy is largely agro-based as agriculture constitutes the backbone of the rural livelihood security system. With more than 100 million farm holdings, agriculture supports more than 60 % of the total population in India and contributes about 19% to India's GDP. With cotton at the forefront, it contributes about 16% of the total agricultural-crop of the country with India possessing the largest area under cotton cultivation which is nearly 9 million hectares. Therefore, it becomes increasingly crucial to ensure a good annual harvest as it holds a significant chunk in the exports in the Indian economy. Each year, massive capital investments are required in terms of manpower as extensive care is required by the line sowed cotton plants during their early development stages. Any obstruction such as weeds can significantly affect and hinder their growth. Additionally, while operating here, the moisture retentive black soil poses difficulty to work in due to its extremely marshy nature. This makes the task of weeding very difficult and labour intensive. Hence, it becomes necessary to incorporate automation in this sector and provide a sustainable solution to address this grave issue and ensure good yield of cotton plants by uprooting weeds in a more economical fashion. Refer Figure 3.1 & 3.2 for cotton fields and weed presence in fields.

Figure 1.3.1: Line Sowed Cotton Fields

Figure 1.3.2: Weeds Present in the Field

1.4 OBJECTIVES

- ***Designing & developing a robot capable of traversing in marshy terrains.***
- ***Developing a computer vision model to facilitate cotton plant identification.***
- ***Developing a path planning and mapping algorithm for autonomous maneuvering of the robot in alien terrains.***
- ***Developing a weed uprooting mechanism to uproot weeds up to 12 cm in height.***

The primary objective of this project is to develop a solar power assisted autonomous weed killing robot. The robot specifications should be such that it can traverse in marshy black soil while avoiding sinkage and move freely amongst the cotton grids. The agenda of developing this robot caters to uprooting weed around young cotton plants to prevent hampering their growth. The problem scope and objectives that are dealt with as part of this research project are as follows in Table 1.4.1:

Problem Scope to be Dealt With	**Specification**
Field Size (Working Area)	25 x 30 sq. ft
Soil Density	1.81 - 2.08 g/cm^3
Operation Time	30-35 mins
Weight	Under 10 Kgs
Operational Stage	Budding cotton plants (H= 2-3 ft)
Grid Size for Each Plant	20 cm x 20 cm

Table 1.4.1: Specifications for Project Objectives

For the purpose of this project a field was planted with cotton seeds to serve as our working area and facilitate manual curation of dataset to suit our requirements. Refer to Figure 1.4.1 for the field working area in Jammu.

Figure 1.4.1: Field Working Area in Jammu

2.1 DATASET & WORKING AREA MATRIX

Cultivating our own cotton field sowed in matrices was crucial for the development of the project to procure data and understand the practical obstructions the robot might face while maneuvering autonomously. It yielded reliable data spread across weeks to record all stages of plant growth for long-term considerations. Figure 2.1.1 & 2.1.2 demonstrate the theoretical and actual grid size and matrix obtained with line sowed cotton.

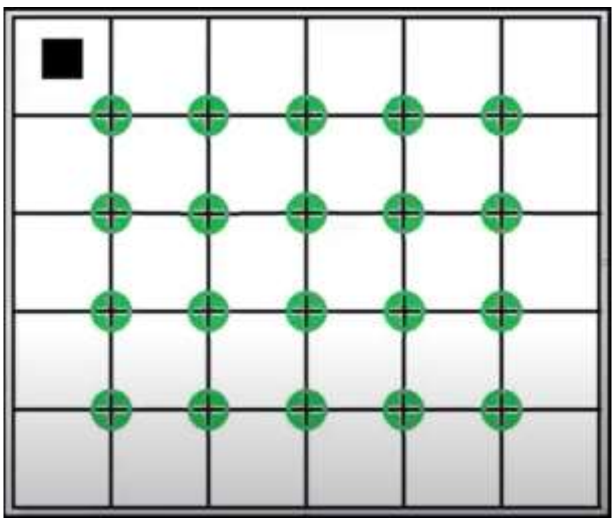


Figure 2.1.1: Theoretical Grid Arrangement of Cotton

Figure 2.1.2: Actual Grid Obtained in Field

To suit the requirements of our robot and train it precisely instead of availing the dataset available on the internet, we manually curated our own dataset and video footage to handle real-life situations in a more concrete way and make our model robust. While procuring the images, extensive care was given to collect the photographs at a specified height and angle of 18 inches and 30 degrees from the vertical respectively. This was ensured in order to accurately replicate the point of view of the camera module on the robot and hence obtain better results. Some images can be seen in Figure 2.1.3 which demonstrate the various situations our robot might encounter itself in: plain terrain, rocky terrain, marshy terrain and area with a thick growth of weed. To access the full dataset, refer to the appendix.

Fig. 2.1.3.1

Fig. 2.1.3.2

Fig 2.1.3.3

Fig. 1.5.3.4

Figure 2.1.3: Images Captured from Field to Create Dataset

2.2 ROBOT MODEL & ASSEMBLY

With the specifications laid out the designing considerations were obtained to aid in the development of the CAD model of the robot. Refer to Figure 2.2.1 & 2.2.2 for the assembly.

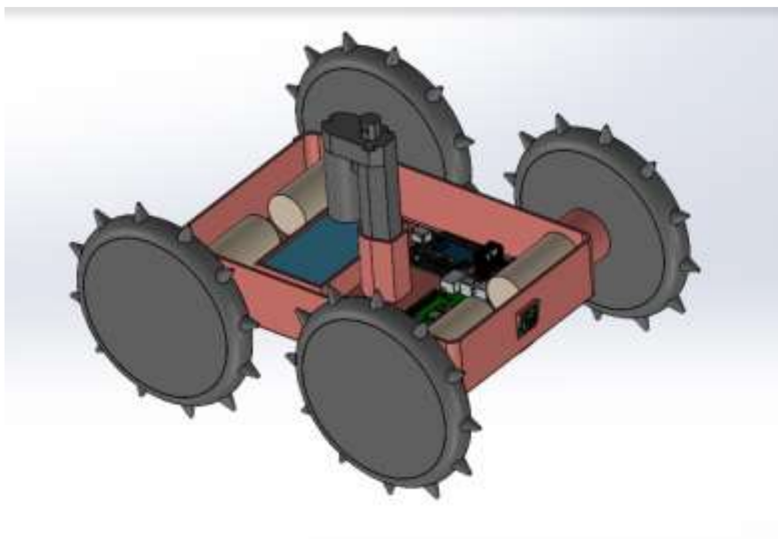


Figure 2.2.1: CAD Model of Robot Assembly

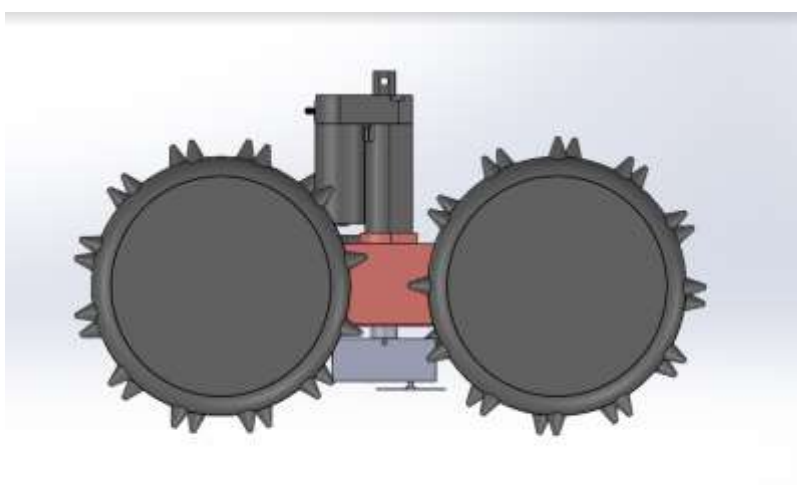


Figure 2.2.2: Side View of Robot Assembly

The list of components incorporated in this assembly are as follows as found in Table 2.2.1:

Component	**Quantity**
Wheels	4
Actuator Stroke	1
Linear Actuator	1
Arduino Uno	1
Battery	1
Fan Blade	1
Body Casing	1
Raspberry Pi 4B with Camera Module	1
Connector Rod	1
Motors	5

Table 2.2.1: List of Components in Robot Assembly

Refer to the appendix for the drawings of all the components in the assembly.

2.3 CALCULATIONS

The assumptions and design considerations taken into account while performing the calculations have been listed below in Table 2.3.1

Design Consideration	Value
Weight of the Robot	100 N
Wheel Radius	0.08 m
Efficiency of Transmission (%)	90
Coefficient of Friction	0.65
Coefficient of Rolling Resistance	0.15
Target Gradability (%)	50
Target Velocity (m/min)	10
Frontal Area of Robot (m^2)	0.02
Density of air (kg/m^3)	1.225

Table 2.3.1: Design Considerations & Parametric Values Assumed

For deciding the required specifications of the motor, we'll estimate all the loads acting on the robot.

Total $\text{Load}_{\text{Robot}}$ = RR + AR + GR

RR estimation:

$$RR_{Robot} = \mu * Weight_{Robot}$$

$$RR_{Robot} = 0.15 * 100 = 15 \text{ N}$$

AR estimation:

$$AR_{Robot} = ½ *\rho*A*V^2*Cd$$

$$AR_{Robot} = ½ * 1.225 * 0.02 * (10/60)^2 * 1$$

$$AR_{Robot} = 0.003 \text{ N}$$

GR Estimation:

$$GR_{Robot} = Weight * \sin(\boldsymbol{\alpha})$$

$$GR_{Robot} = 100 * \sin(26.56°) = 44.72 \text{ N}$$

Total Load$_{Robot}$ = $RR_{Robot} + AR_{Robot} + GR_{Robot}$

$= 15 + 44.72$

$= 59.72$ N

Torque Required on Wheels (T_W) = Total Load$_{Robot}$ * Radius$_{Wheel}$

$= 59.72 * 0.08$

$= 4.77$ N-m

Torque to be Supplied by Motor (T_M) = T_W/ (Efficiency*Gear Ratio)

$= 4.77/ (0.9*1)$

$= 5.3$ N-m

Torque Supply per Motor = T_M/Number of Motors

$= 5.3 / 4$

$= 1.325$ N-m

2.4 WORK STRATEGY

2.4.1 Robot Path Traversal

The robot path traversal algorithm traces out & maps the path to be travelled by the robot. The algorithm deployed for the same is A* search algorithm which is a graph traversal and path search algorithm. The heuristics incorporated here define how the robot

Heuristic = w (Manhattan Dis. to Goal State) + (1-w) (Perpendicular Dis. to S1-G1 Line)

The flowchart for the working of the path traversal algorithm can be seen in Figure 2.4.1

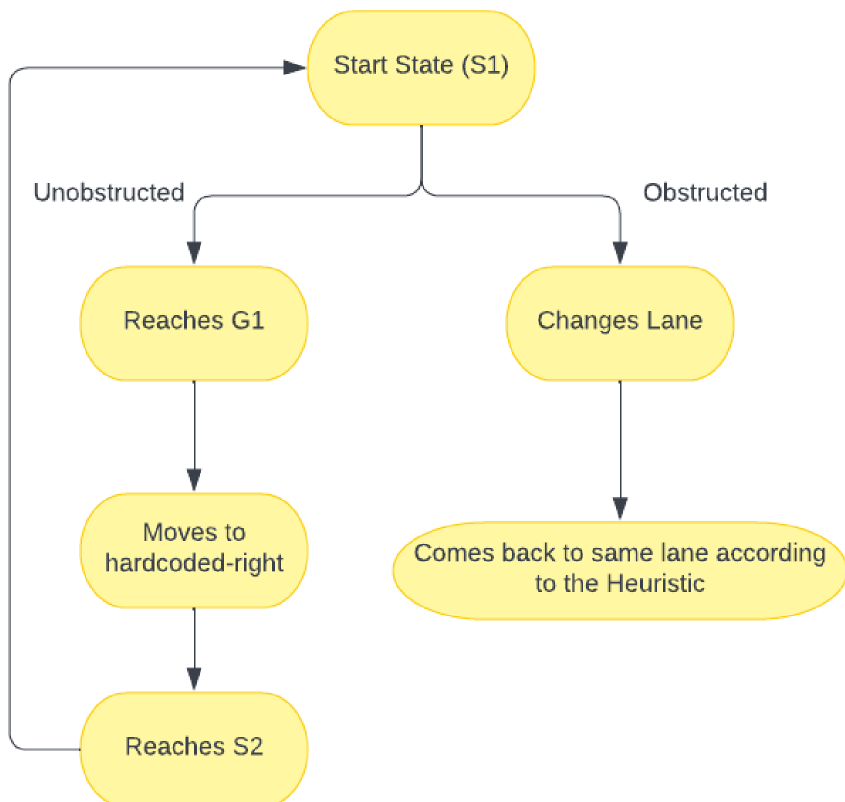


Figure 2.4.1: Working of Path Traversal Algorithm

2.4.2 Plant Identification & Detection

The computer vision model employs ResNet architecture as its image processing algorithm. The external camera module which dangles in the absolute front of the robot vehicle has been placed in such a way so as to avoid any overlooking of weeds. The camera module captures and inputs video feed to the computer vision model at an interval of 10 frames for processing and the output identifies and labels the plant as ‘Cotton’ or ‘Not Cotton’. Thus, if a weed is identified the response for triggering the weed uprooting mechanism is set into motion. Figure 2.4.2 displays the algorithmic flowchart of how it operates.

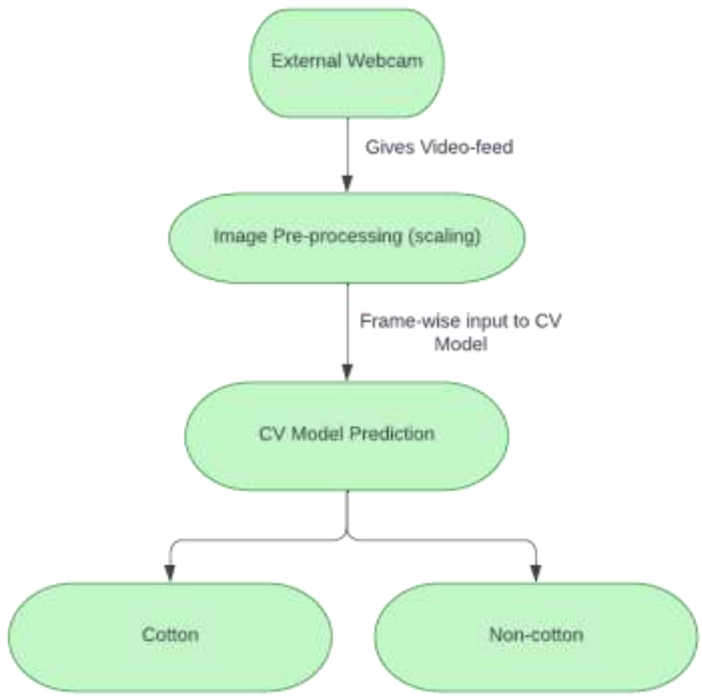


Figure 2.4.2: Workflow of CV Model

2.4.3 Weed Uprooting Mechanism

The weed uprooting mechanism that has been integrated with the system includes a motor blade which is lowered via a linear actuator of maximum stroke length of 100 mm. In case the computer vision model detects any weed, the robot is immediately brought to rest and the mechanism is set into motion. The Raspberry Pi relays the signal to L298 via Arduino Uno while simultaneously triggering the linear actuator. The pictographic representation has been depicted in Figure 2.4.3 which can be found below.

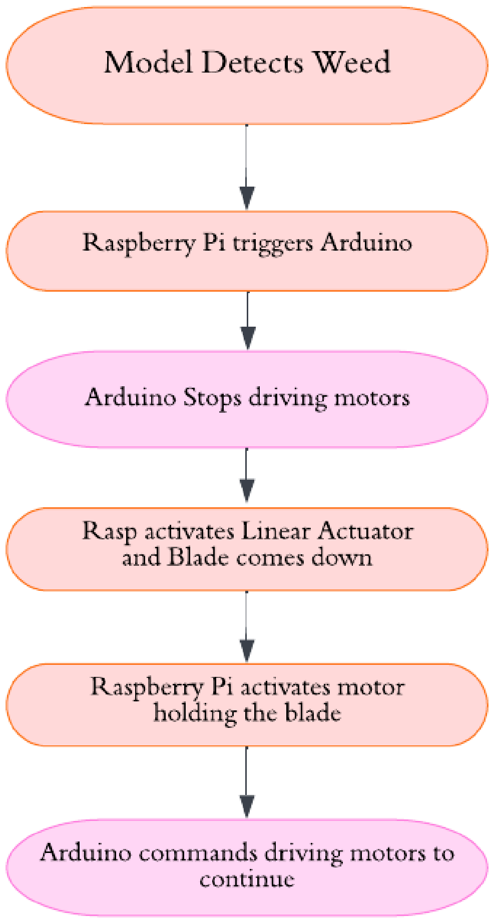


Figure 2.4.3: Workflow in Case of Weed Detection

2.5 CIRCUIT DIAGRAMS & SPECIFICATIONS

The circuit diagrams are crucial in representing the essence of the working of the robot. Various mechanisms operate in unison to optimally function the robot in its task of uprooting weeds while deployed in the working area. Three primary circuits have been integrated to perform and set communication which include:

Raspberry Pi – Arduino Uno Communication

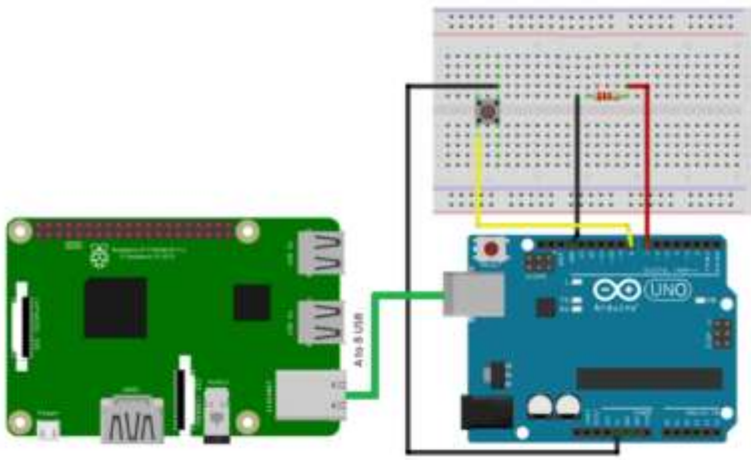
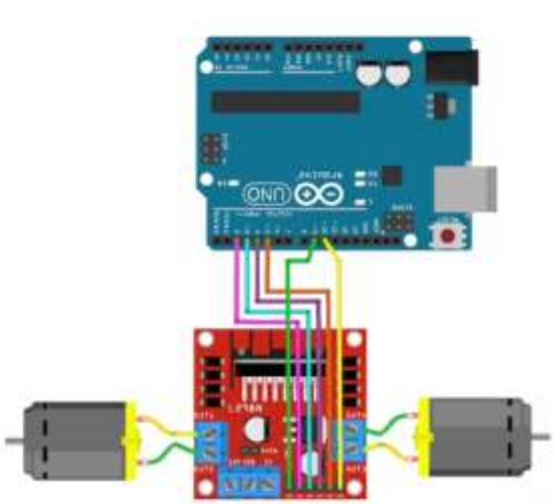


Figure 2.5.1: Hardware Connection b/w Raspberry Pi & Arduino

Figure 2.5.1 depicts the hardware connection between Raspberry Pi & Arduino Uno. It has an added camera module which provides the input to the processing unit and is evaluated by the Computer Vision Model. The command is further relayed via Arduino to perform the necessary action. The specifications of the components are listed below:

- Raspberry Pi 4 Model B; 4 GB, ARM-Cortex-A72 4 x, 1.50 GHz, 4 GB RAM, WLAN-ac, Bluetooth 5, LAN, 4 x USB, 2 x Micro-HDMI
- Breadboard with 400 Tie Points (BB-801)
- Arduino Uno R3 ATmega328P with USB Cable

__Arduino Uno – Motor Driver – Motor Communication__



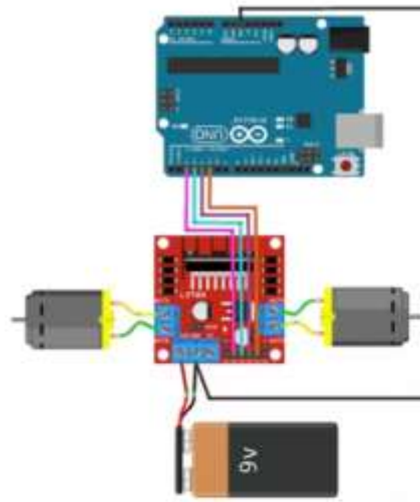


Figure 2.5.2: Circuit for Variable Speed Control   Figure 2.5.3: L298 & Arduino Powered Separately

Figure 2.5.2 & 2.5.3 denote the hardware connection for variable speed control of motors and the power supply of the circuit respectively. The Raspberry Pi relays commands to the Arduino to control the motors and the robot and a power supply of 12V is being provided. The specifications of the components are as follows:

- Orange Planetary Gear DC Motor 12V 92RPM 234.7 N-cm PGM45775-50.9K
- Motor Driver L298 dual H-bridge driver chip.
- Panasonic Li-Ion 2000mAh type, 1900mAh min, pre-charged rechargeable AA batteries.
- 8 CELL 1.5v AA Battery Case Holder, Battery Holder Box with Cover ON/Off Switch

Arduino Uno – 2 Channel Relay – Linear Actuator Communication

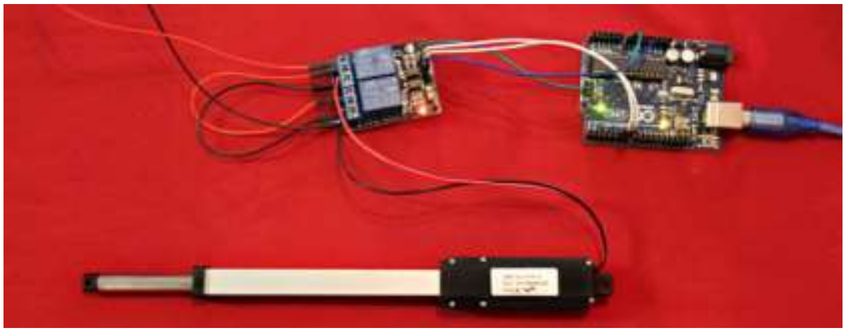


Figure 2.5.4: Hardware Connection for Linear Actuator

Figure 2.5.4 represents the hardware connection between the processing unit, to a 2-channel relay which further activates the linear actuator. This connection is triggered by the computer vision model when it detects any nearby weed. The linear actuator gently lowers the piston to consequently lower the blade for any removal of weeds detected. The specifications of the components used for this circuit include:

- Linear Actuator Stroke Length 100MM,7mm/S,1500N,12V
- 5V 10A 2 Channel Relay Module Shield for Arduino ARM PIC AVR DSP Electronic

3.1 OBSERVATIONS

When the robot was deployed in the field it was observed that with the non-conventional wheel designs that have been used in the robot with the spikes, we were able to successfully maneuver in the marshy terrain. The robot did not wobble much and remain stabilized while traversing. The rocky terrain was within the scope of expectations leading to enhance the motor design considerations. However, the speed output expected was slightly lower relative to the theoretical value.

When the camera was tested in the field to ensure high performance of the computer vision model, the following results were obtained as seen in Figure 3.1.1:

Figure 3.1.1: Output from Computer Vision Model

The traversal of the robot from the start state to the goal state with continuous updating for each grid was successful with the robot completing this distance without waving off its path. Therefore, it was observed that integration of A* search algorithm for path planning was a success.

For removal of weed the mechanism in place we aim to be able to cut it down to its stem, with the remains still present near the main plant body. It was safe to conclude that the robot is capable of doing this task while testing the circuit of linear actuator separately from the body.

As for the components, the 3D printed parts include customized wheels and the robot body as observed in Figure 3.1.2. The printed casing was observed to be a little deviated from the CAD model due to some errors in the FDM 3-D printer.

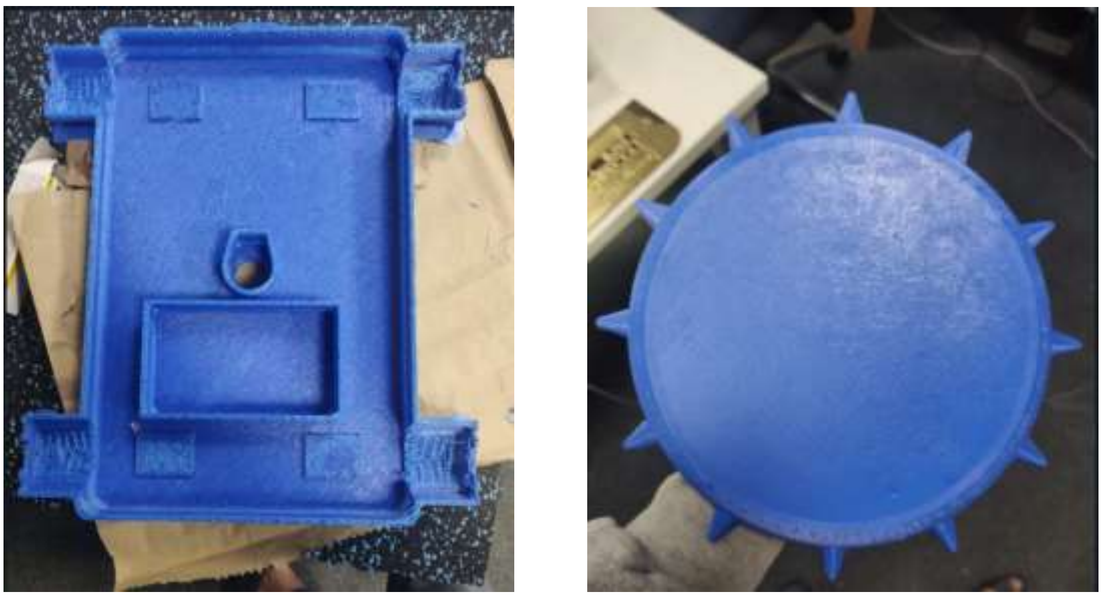


Figure 3.1.2: 3-D Printed Wheels and Robot Casing

3.2 RESULTS & DISCUSSION

The wheel was successfully manufactured using the FDM 3D printer available in the tinkering lab. The material was chosen to be Polylactic Acid. Table 3.2.1 shows the parameters for 3-D printing.

Table 3.2.1: Parameters for FDM

S. No.	Parameter	Value
1	Infill Density	20%
2	Infill pattern	Triangle
3	Printing Temperature	210 ℃
4	Build Plate Temperature	60 ℃
5	Printing Speed	50 mm/s
6	Top Thickness	0.3 mm
7	Bottom Thickness	0.6 mm

The base was not successfully printed due to some technical problem in the nozzle. The parameters were chosen to be the same as that of the wheel. We observed an abundance of pores in the base which significantly reduced its strength.

Figure 3.2.1: Wheel Assembly

Figure 3.2.1 shows the wheel assembly. The keyway was purposely designed to be of a tight fit to prevent slipping. This resulted in a great torque transfer from the motor to the wheels.

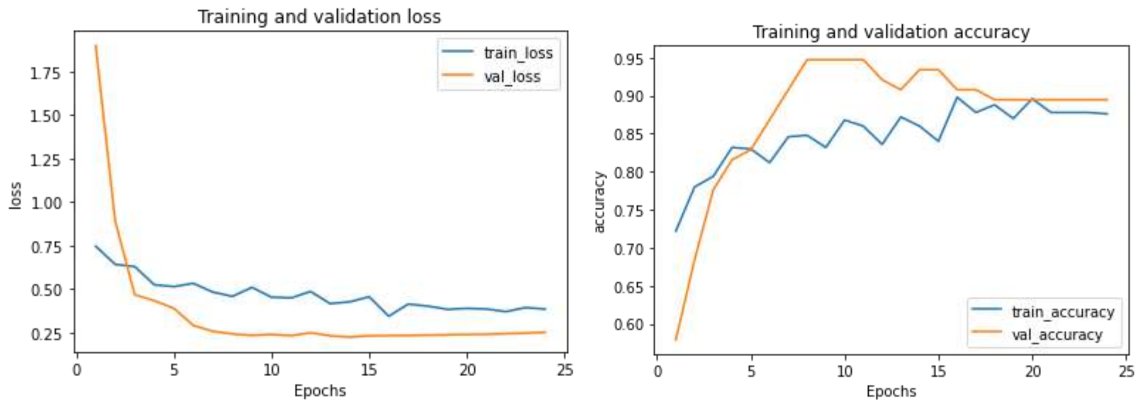


Figure 3.2.2: Performance of Computer Vision Model

Using the site-collected dataset, we trained a computer vision model to recognise cotton plants. Its accuracy in both training and validation was 90.1% and 89%, respectively. The plot shown above in Figure 3.2.2 displays how the accuracy and loss vary with training epochs. We can observe that, while converging without overfitting, our validation loss is less than our training loss. Furthermore, it is implied by the plot, it is neither exploding or becoming stranded.

4.1 CONCLUSION

This work proposed the development of a weed uprooting robot with current state-of-the-art localization and mapping techniques along with a well-equipped computer vision model to identify and differentiate between cotton and weed. After an intensive research and development phase spanning over 12 weeks we were able to develop a working prototype characterized and trained by the dataset which was manually curated to specifically suit the needs of the robot. The scope of this project focuses on the early developmental stages of young cotton plants with a height of about 25 inches. After developing a deeper product sense, segregating the current targets from future goals was facilitated with the research to enhance the prototype extending to the next semester. Since there were about four major considerations in this robot the following could be mapped out for the domains:

Robot Design:

The robot body was deliberately made small for efficient maneuvering in between the narrow channels. With proportionately larger wheels attached at a small angle, a degree of stability was imparted to the model to avoid any toppling. A protruding camera in front of the robot relays the visual input to Raspberry Pi model so that the robot does not miss or cross any potential weeds along the way.

Cotton Identification Model:

It is safe to conclude that by employing the ResNet Architecture with a dataset of over 800 images, an accuracy of 89% was achieved. The computer vision model was successful in identifying the plants even in a destabilized self-captured video input. Further enhancements in the model have a direct positive correlation with the increasing number of epochs and quality data.

Traversal & Path Planning Algorithm:

The A* traversal algorithm employed in the robot includes simple linear motion with a restricted degree of freedom of movement to avoid wandering away from the established grid structure. When it reaches the end of a channel, it takes a 90 + 90 degree turn towards the right following the channel yet again. The requirement of 3D localization in agriculture is quite rare with research still premature. The integration of localization & mapping algorithm with the model is still underway with a tremendous potential to grow.

Weed Uprooting Mechanism:

The current weed uprooting mechanism employs a rotatory blade and a linear actuator which is gradually lowered in case of presence of weed. The output from the motor is successfully converted by the actuator and the blade cuts down the weed from surface level. A deeper uprooting of weed takes place in soil areas with a soft texture which can be penetrated by the blade with ease and without suffering any damage.

4.2 FUTURE SCOPE OF WORK

The autonomous weed killing robot developed yielded exciting results but also revealed pathways for improvement and future scope of work. Some problems that were faced during the fabrication phase of the robot need further diving into for either enhancement or troubleshooting. There remains much scope to improve the accuracy of the computer vision model by deploying latest algorithms and harboring access to ‘Agastya’ supercomputer to accelerate model training and validation.

Implementation of path planning and traversal algorithms for localization and mapping of alien territories requires expertise in SLAM, an algorithm which is still premature in context to agriculture and forestry. By modifying the design of the model to accommodate more cameras, we may be able to reduce the engagement of a single camera for multiple visual tasks. By enhancing the power supply and establishing a solar-powered recharging station to ensure constant power availability we may procure video feeds from multiple perspectives for training an end-to-end model for weed-crop identification and detection. Regular monitoring by the robot and relaying the feed to a database, a library of weed and cotton plant images can be curated to bolster the research of crop-weed differentiation.

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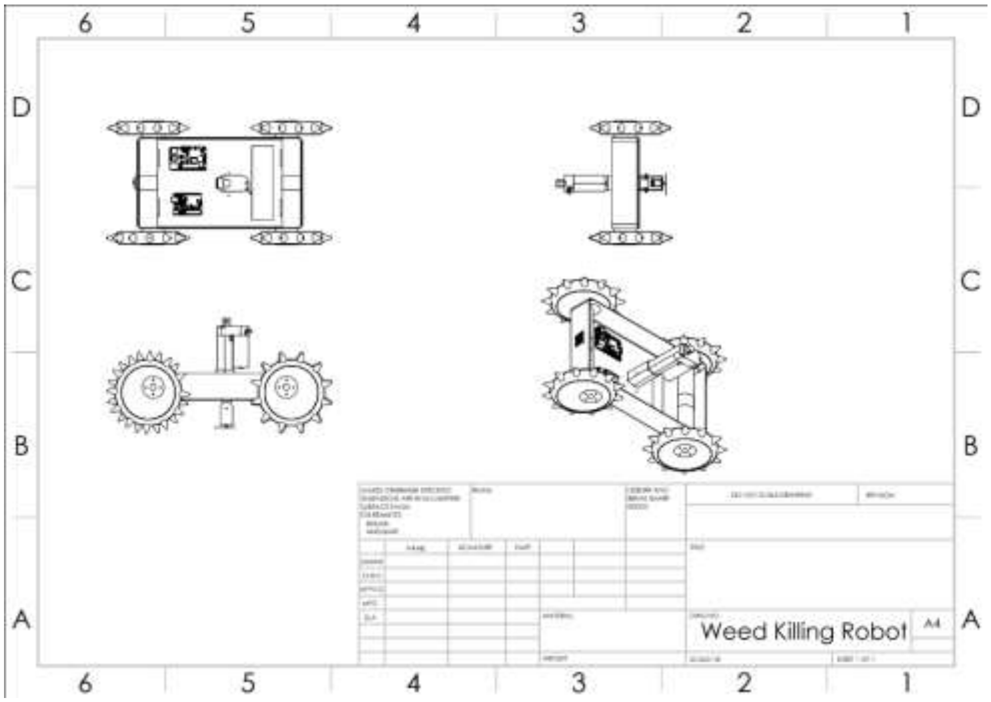
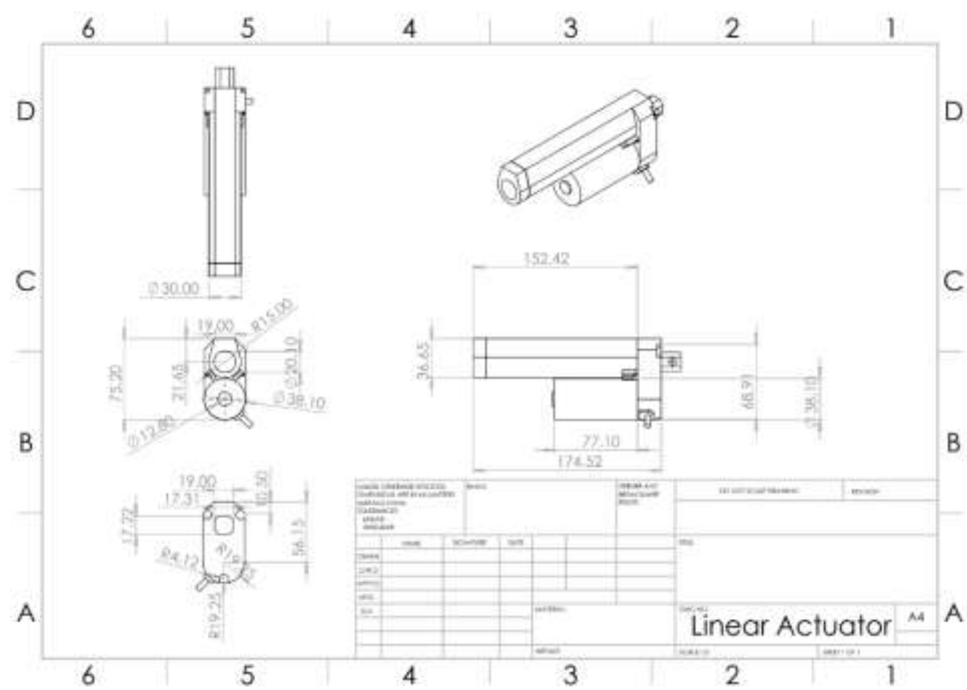
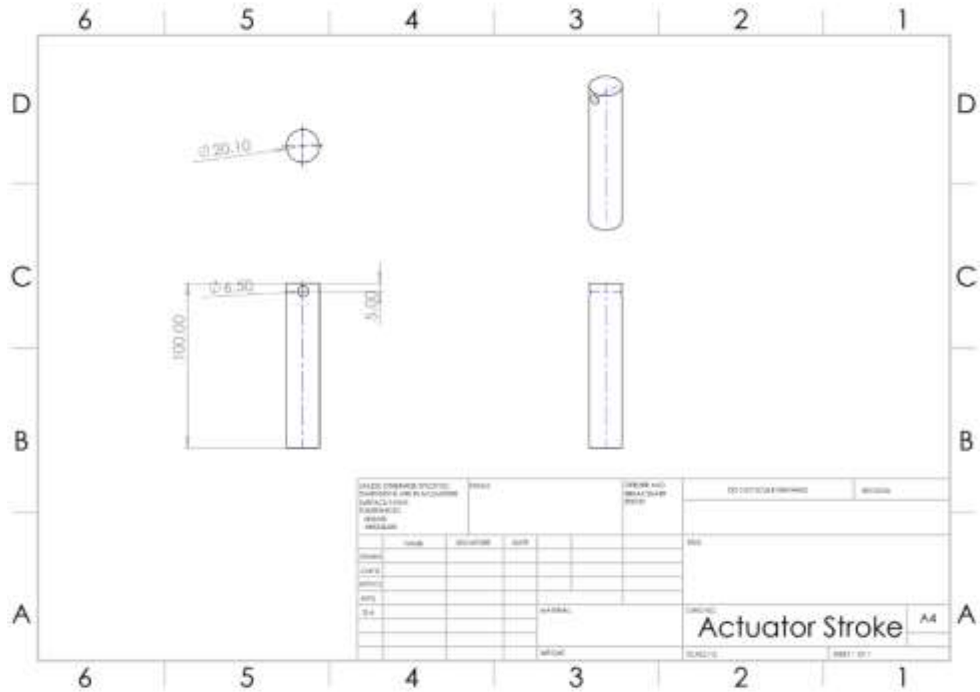
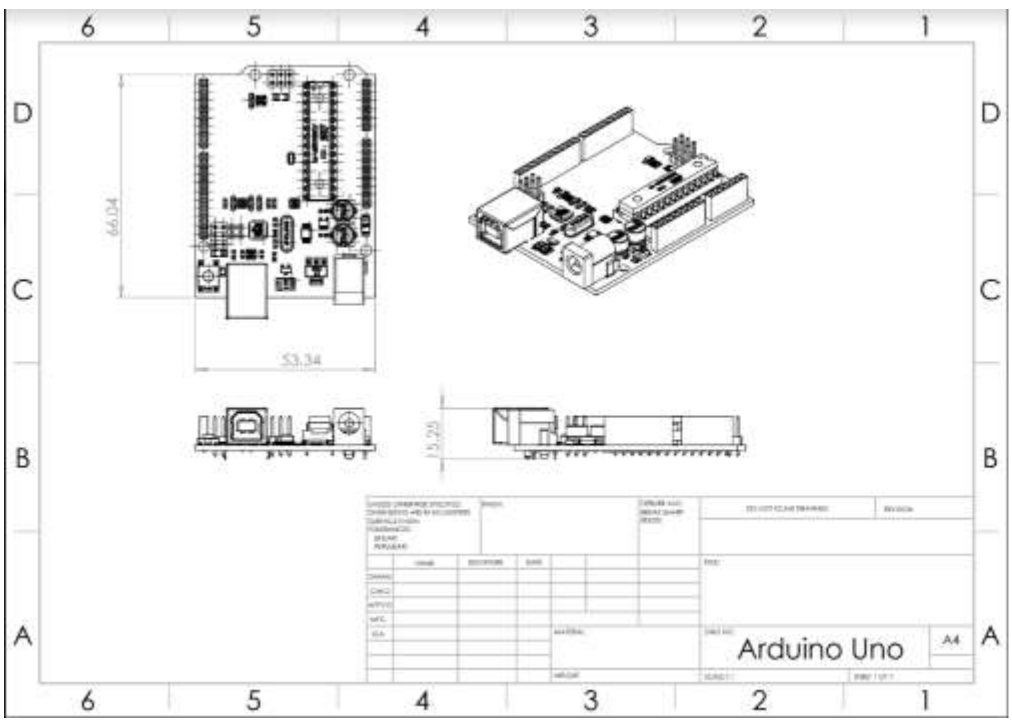
Appendix


Weed Killing Robot
A4

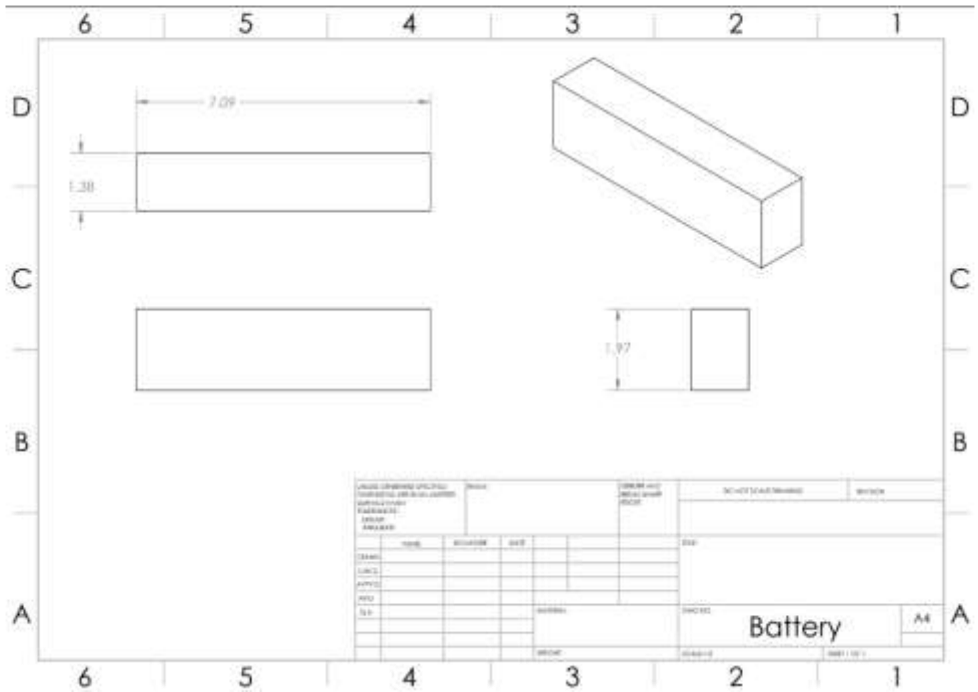

152.42
36.65
68.91
38.10
77.10
174.52
30.00
19.00
R15.00
20.10
38.10
75.20
21.65
12.80
19.00
17.31
10.30
17.72
56.15
R4.12
R19.25
Linear Actuator
A4

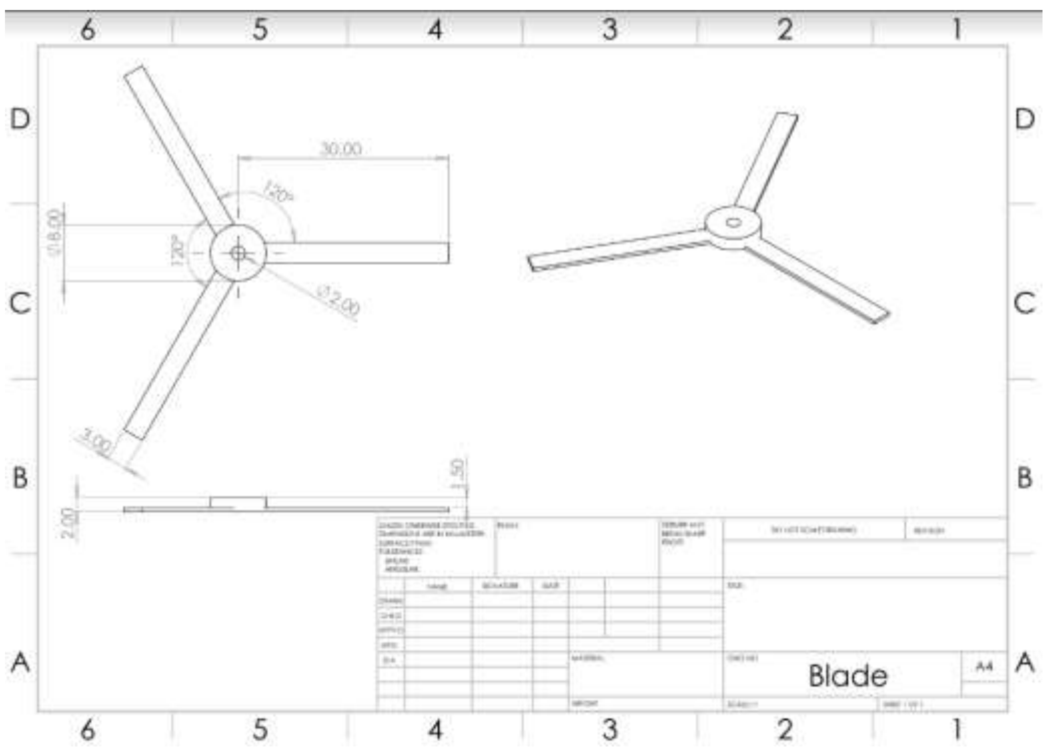


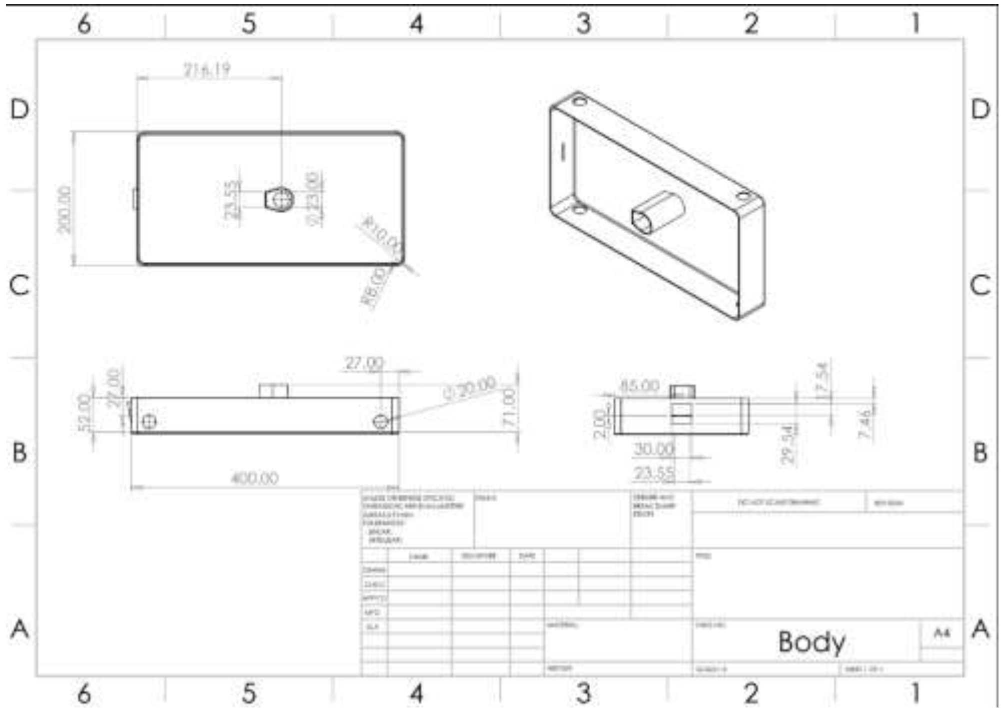
Ø20.10
Ø6.50
100.00
5.00
Actuator Stroke
A4

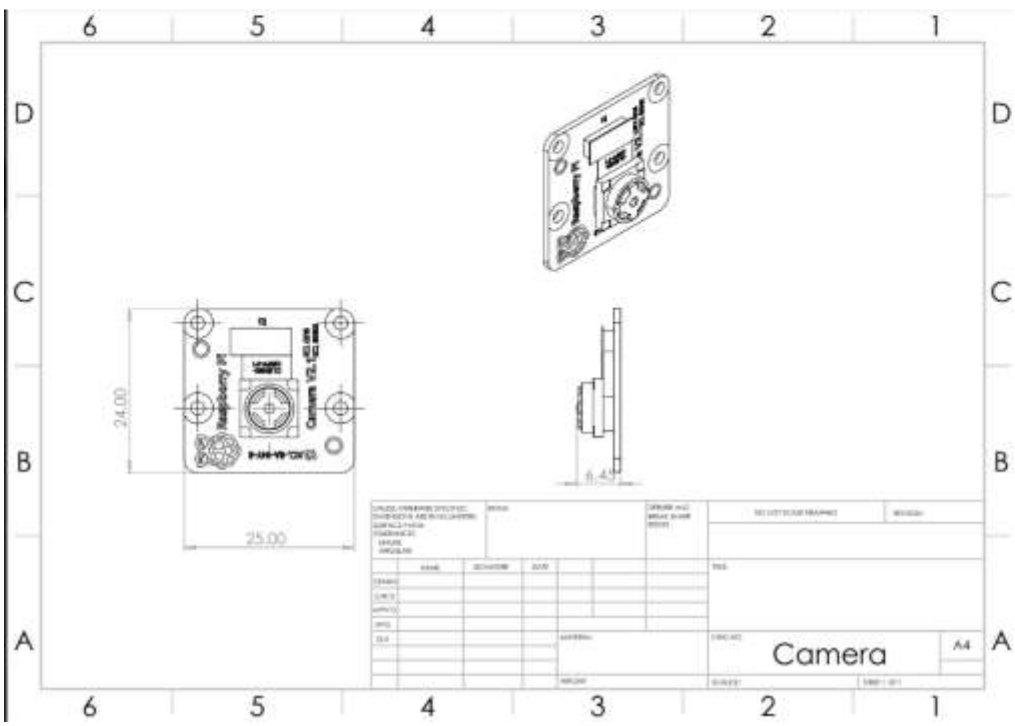


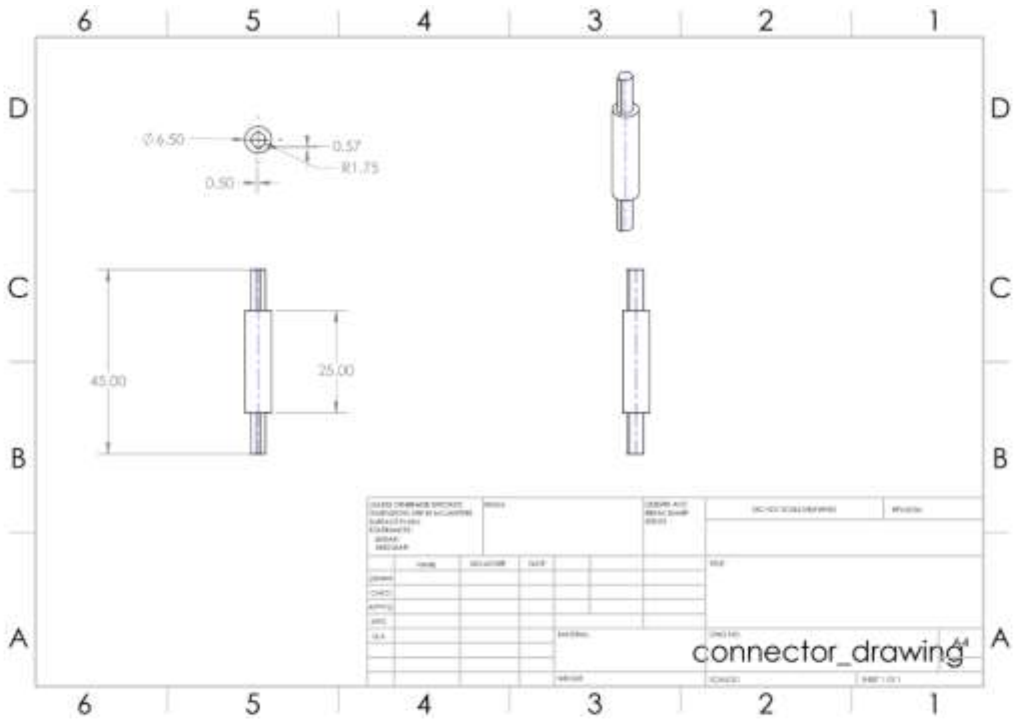
66.04
53.34
15.25
Arduino Uno
A4


7.09
1.38
1.97
Battery
A4

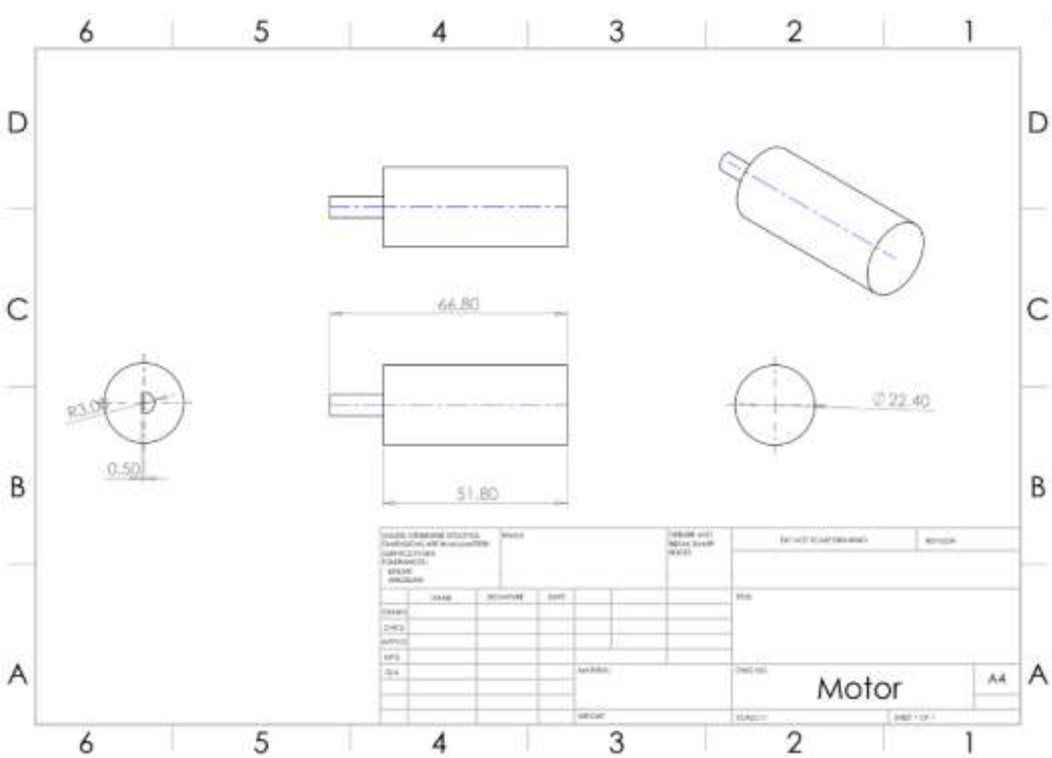

30.00
120°
120°
Ø18.00
Ø2.00
3.00
1.50
2.00
Blade
A4


216.19
200.00
23.55
∅23.00
R10.00
R8.00
27.00
52.00
27.00
∅20.00
71.00
400.00
65.00
7.54
2.00
29.54
7.46
30.00
23.55
Body
A4

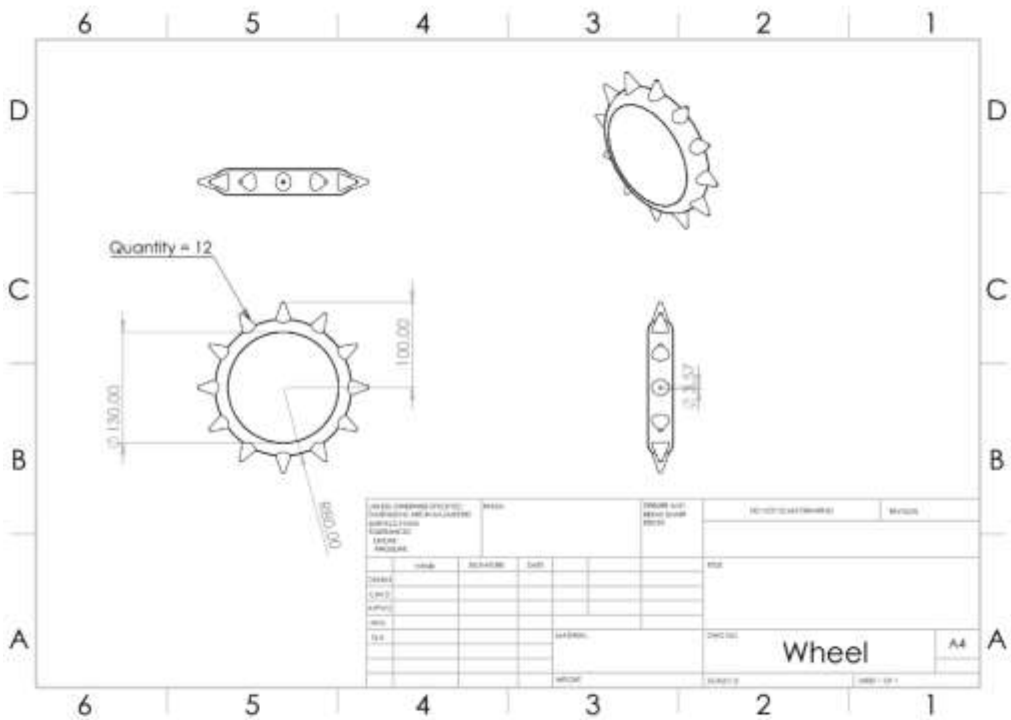

24.00
25.00
6.45
Camera
A4



Ø6.50
0.57
R1.75
0.50
45.00
25.00
connector_drawing
A4



66.80
51.80
R3.00
0.50
Ø22.40
Motor
A4


Quantity = 12
100.00
Ø 130.00
Ø 3.57
Wheel
A4