“TEABOT” - TEA PLANTATION PRESERVATION USING AN INTELLIGENT ROBOT : A RESEARCH

TMP-23-044

Project Proposal Report

Gunawardana I.I.E

B.Sc. (Hons) Degree in Information Technology
Specialized in Software Engineering

Department of Computer Science and Software Engineering

Sri Lanka Institute of Information Technology
Sri Lanka

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DECLARATION

I declare that this is our own work, and this proposal does not incorporate without acknowledgment any material previously submitted for a degree or diploma in any other university or institute of higher learning, and to the best of our knowledge and belief, it does not contain any material previously published or written by another person except where the acknowledgment is made in the text.

Name	Student ID	Signature
Gunawardana I.I.E	IT19973470	

The above candidates are carrying out research for the undergraduate Dissertation under my supervision.

---------------- 23/04/2023

Signature of the supervisor Date

ABSTRACT

Tea cultivation is the one of the most significant export products contributing to the GDP in Sri Lanka. Among other export crops, tea has a well-known history and the Ceylon Tea is the well-known brand in the world. Ceylon Tea is having a popular market in the world. Sri Lanka is having a mild weather and a rich soil to grow tea. Because of that, the Ceylon Tea is having an identical taste which loves by people in other countries. In the past decades, Sri Lanka had a plenty of human resources to maintain large scales of tea estates. As time goes by, with the industrial revolution in the country. The people gradually started to move for different occupations. Rather than other crops, tea needs a good maintenance and it highly costs. With the decrease of laborers, people were unable to maintain the tea estates. It affected to decrease the crops. Some estate owners started to move to plant different crops which having a less maintenance cost. For the export market, it was highly affected. TeaBot is a well developed autopilot robot to replace the human resources for watering and fertilizing for large scale tea estates. Among other robots, the TeaBot is specially designed to operate in off road conditions and no need a highly arranged clear paths to navigate. The robot is mainly doing the watering and fertilizing the tea plants respectively. Since the tea plants need a continuous hydration and nutritions to provide the maximum crop. The robot is increasing the efficiency and decrease the water and fertilizer wastage. The TeaBot can identify the path to navigate and identify the end of the plant stems and watering the plants efficiently.

Keywords – ROS, Tea, Robot, Liquid Fertilization, PID, Motor Controlling, Raspberry Pi, I2C, Arduino

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LIST OF ABBREVIATIONS

ROS	Robotics Operating System
2WD	Two wheel drive
4WD	Four wheel drive
2WS	Two wheel steer
4WS	Four wheel steer
LKR	Lankan Rupees
PID	Proportional–Integral–Derivative
DC	Direct Current
GDP	Gross Domestic Product

1 INTRODUCTION

1.1 Background and Literature Survey

Tea cultivation is the one of the most significant export products which is contributing to the GDP in Sri Lanka. Among other export crops, tea has a well-known history and the Ceylon Tea is the well-known beverage in the world. As a result of industrial revolution, laborers were decreased for the tea plantations. The tea estate owners were unable to maintain the tea estates. So, it affected to decrease the crops. TeaBot is an autopilot robot to replace the human resources for watering and fertilizing for large scale tea estates. Among other robots, the TeaBot is specialized to operate in off road conditions and no need clear paths to navigate. The robot is mainly doing the watering and fertilizing the tea plants respectively. The tea plants need a continuous hydration and nutrition to provide the maximum crop. The robot is increasing the efficiency and decrease the water and fertilizer wastage.

In the robot controller, the navigation part is a significant item of the robot. Rather than others, this robot can identify the track and navigate between the tea plants in off road conditions. The robot no needs a highly arranged leveled paths to navigate. The TeaBot uses PID controller to fine tune the navigation and sensors to read angles and the speed. The main robot controller is operating on top of ROS using a Raspberry Pi minicomputer. The robot controller includes hazards identification to emergency stop to prevent the robot hardware components and notify it to the administrator.

TurtleBot3 using LiDAR sensor and created map will be used in navigation tasks for obstacle avoidance using ROS[1]. DC motors powered and controlled by the raspberry pi using soil moisture sensor for automatic irrigation, PIR sensor, and rain fall sensor[2]. Autonomous Mobile Robot traveling on a rail and the system is running on top of ROS[3]. Four-wheel and front wheel steering robot using GPS and it is 150kg of weight[4]. Trajectory tracking system with four-wheel skid-steering robot using PID, Raspberry Pi and wifi[5]. The BoniRob autonomous navigation agriculture robot over row-based cultures, using sensors, lidar, wifi and Intel Atom embedded pc for computing[6]. The RagriBot for row type seed sowing and the power is supplied by the solar[7]. Agriculture robot for row type autonomous agriculture work and the size is very large[8]. Four-wheel drive agricultural mobile robot with in wheel motor and non-gear and four-wheel steering[9]. The processing is done by arduino, AgriBot including four-wheel steering (4WS) and it is a large size robot. The center of gravity is in a bit upper position[10]. Thorvald II Four-wheel steering strawberry harvesting agriculture robot[11]. Four-wheel steering with center arms to pluck the crop[12]. Four-wheel agriculture robot, with GPS enabled[13]. Autonomous Seed Sowing agricultural robot using Arduino and eligible only for flat roads[14]. Four-wheel drive mobile robotic platform intended for weed monitoring including front wheel steering and most suitable for green houses[15]. Agriculture robot for flat and rough terrain. Autonomous greenhouse mobile robot, front-wheel-steering (FWS) and rear-wheel-steering (RWS), all four-wheel steering (4WS) [16]. PID controlled four-wheel drive greenhouse agriculture robot[17]. Agri robot Crop Phenotyping powered by a Intel NUC[18]. Solar Powered Autonomous Agricultural Robot for Crop Monitoring and Material Handling[19]. Arduino Uno and Raspberry Pi for agriculture robot[20].

The summarization of prior studies.

1) **Computer :** Raspberry Pi, Intel NUC, Arduino
2) **Wheels :** 6 to 10 inches flat and rough terrain rubber wheels
3) **Wheels Mechanism :** Four wheel drive (4W), two wheel drive (2W), four wheel steering (4WS) and two wheel steering (2WS), Skid steering
4) **Power Supply :** Solar, engine driven, battery powered
5) **Programming Languages :** Python, C++

1.2 Research Gap

According to the previous studies, the robotic controllers were different for different purposes. Most of the robots are suitable for green house environment since the power management and the wheels operation are the most suitable for flat terrain. Using 2W drive not suitable for rough terrain since it need more power for off road levels. The 4W drive is the most compatible one for rough terrain. Using 2WS is a bit challenge when needs to turn the robot in a small space. When using 4WS, it needs more motor power and a mechanism to rotate all wheels. For slope lands, the 4WS mechanism is suitable for drive without sliding horizontal. But using wide and the thread of V shape wheels, the robot can go without sliding horizontal. Using skid steering, no need for complex mechanical design to turn the robot. For flat terrain and a light power, the solar is the most suitable. But for rough terrain and driving under trees is not eligible with solar power. For the computing process, Arduino can only do motor controlling, sensor reading, and work with data retrieving from a cloud. But using ROS with python, the robot can do furthermore processing including image processing. The complete robot can operate as a package and eligible do all the processes in raspberry pi.

Table 1-1: Robots Comparison

Robot	Wheels Mechanism	Power Supply	Computer	Scale	Eligibility for tea fields
Thorvald	4WD, 4WS	12V Li battery (High power)	Dedicated robot control unit	Extra Large (200 kg)	✗
Ragribot	4WD, Skid steering	Solar Power	Raspberry Pi + Arduino	Small	✗
Agribot	4WD, 4WS	12V (High power)	Dedicated robot control unit	Extra Large (150 kg)	✗
BoniRob	4WD, 4WS	12V (High power)	Intel Atom	Extra Large	✗
TeaBot	4WD, Skid steering	12V (Low power)	Raspberry Pi (Python / ROS)	Fair (2 x 2 feet) (30 kg)	✓

For the proposing solution for the TeaBot is having the ability to drive in all terrain. Since the robot will use hard threaded and wide wheels. The wheels mechanism will use the 4W drive and skid steering method. The four wheels will be powered by four motors and the gear system is the sprocket chain gear system for the maximum torque. the robot will use the PID controlling method to fine tune the robot movements. TeaBot will use a (45A) 12V battery for the operations and will use power saving methods. The computational process will be done by ROS using python. The raspberry pi will be used for computer since it is low cost, eligibility of the processing power and need a low power for the computational operations. The robot will design for an affordable price. Overall, the TeaBot will eligible for the all-terrain with the above mechanism.

1.3 Research Problem

Some tea growers and researches tried many research experiments to develop machinery tools to maintain tea estates with a less number of employees. Most of the tools are only specific for single job. In other countries, they have large scale robots for watering, fertilizing and plucking the crop. The problem is the most of the robots are not suitable for some soil and the land conditions. Some lands need expensive arrangements to operate the robot. To fill this gap, a specific methodology will be followed in this research problem. The research problem is, **how to develop the TeaBot to navigate efficiently in off road situations and maintain the power more effective.** This research problem contains several sub sections to focus**.**

1. How to navigate the TeaBot in the correct path without a well-organized track. For an instance, the tea planters no need to make fully leveled tracks or add any additional track to navigate the robot.
2. How to navigate the robot with PID controlling methods using sensors by measuring angles and the speed to maintain a constant speed and navigate smoothly.
3. How to emergency stop the robot if any hazard occurred.
4. How to read coordinates which provided by the computer vision to navigate the robot in the track.
5. How to design the robot chassis to easily move and consume a low power to increase the power saving.

2 OBJECTIVES

2.1 Main Objective

The TeaBot is a robot which will be specially designing to provide solutions for the tea industry. Due to the lack of human resources, this robot will replace to do the jobs in an efficient way. To obtain the optimum crop from the tea plants, the plants should have a proper hydration and NPK saturated fertilizer continuously. The robot will able to move automatically in between the tea plants with computer vision based path identification. The procedure to maintain the tea plants, the liquid fertilizer should add to the end of the stem of the plant and the water and fertilizer should drip about five inches deep. TeaBot will able to do that procedure using pressurized water nozzles and targeting to the end of stem. The computer vision will provide the coordinates of the stem end, the robot controller should provide the realtime speed and the driving angles of the robot to adjust the water nozzles to get the precise target to spray liquid fertilizer. The robot will always trying to maintain a constant speed to spray liquid fertilizer perfect.

TeaBot will have two methods to navigate the robot. First one is the automated way. The computer vision will provide the coordinates to the robot. Then the robot controller will operate the wheels according to those given coordinates with including the sensor readings of the speed and driving angles to maintain a constant speed. This entire process will drive forward the robot in between the tea plant rows. The TeaBot will have hazard identification methods to protect the entire robot. The robot will drag a water hose and it plugs at the back of the robot. If the hose is getting stuck in somewhere, the robot will immediately stop and will notify to the administrator. If the robot will face some disturbance in the road, it will again notify the hazard to the administrator. The second method is the manual remote controller to navigate the robot manually. If the administrator wants to navigate the robot out of the specified track. An app based remote controller including the camera views can navigate the robot remotely and manually by the administrator.

2.2 Specific Objectives

These four objectives must be met to fulfil the above-mentioned main goal.

2.2.1 Development of the robot controller (Hardware)

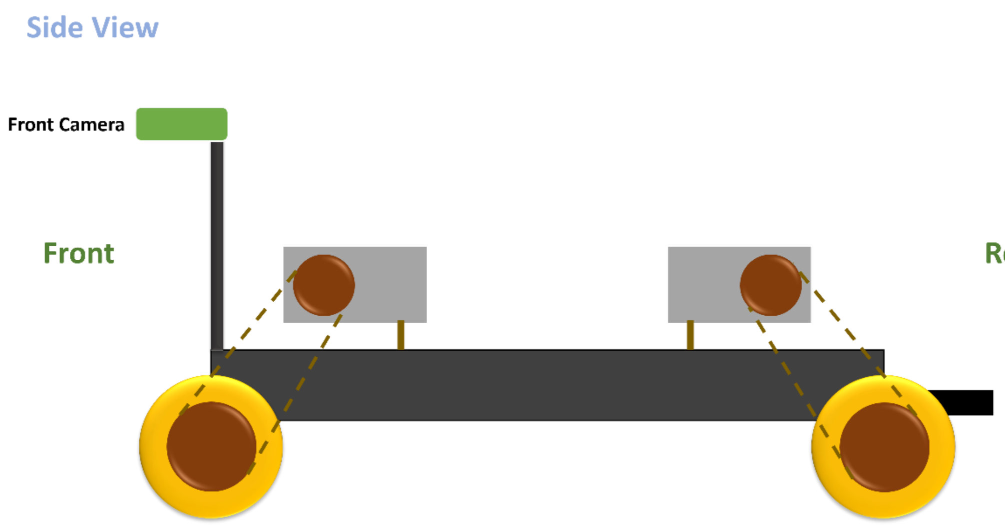

Figure 2-1: Development of robot chassis (Side View)

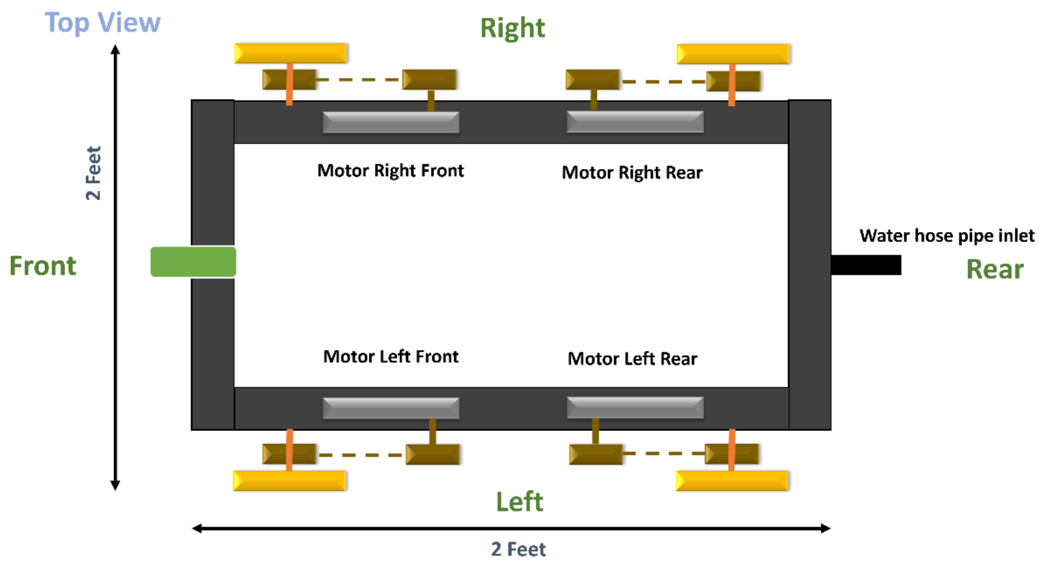

Figure 2-2: Development of robot chassis (Top View)

The robot consists with an iron frame including four eight inches wheels to maintain a rigid body with a fixed height and a proper ground clearance. All the four wheels are motor powered and the front and rear wheels are parallelly connected left and right separated. Using all motor powered four wheels will increase the torque and the power of the robot to drive in off road conditions. The rear of the robot will carry the water hose. The motors and wheels are driving with sprocket and chain to maintain a proper gear ratio to increase the torque.

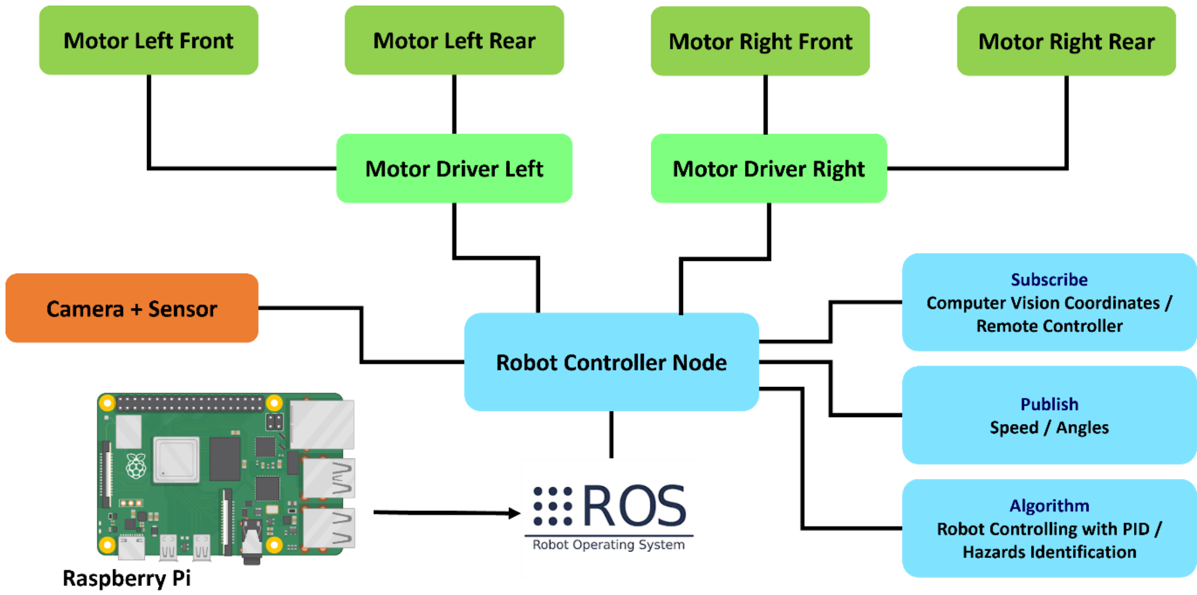

Figure 2-3: Robot Controller Overview

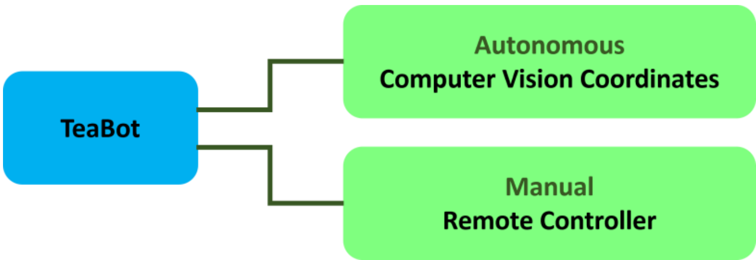

Figure 2-4: Controller autonomous and manual

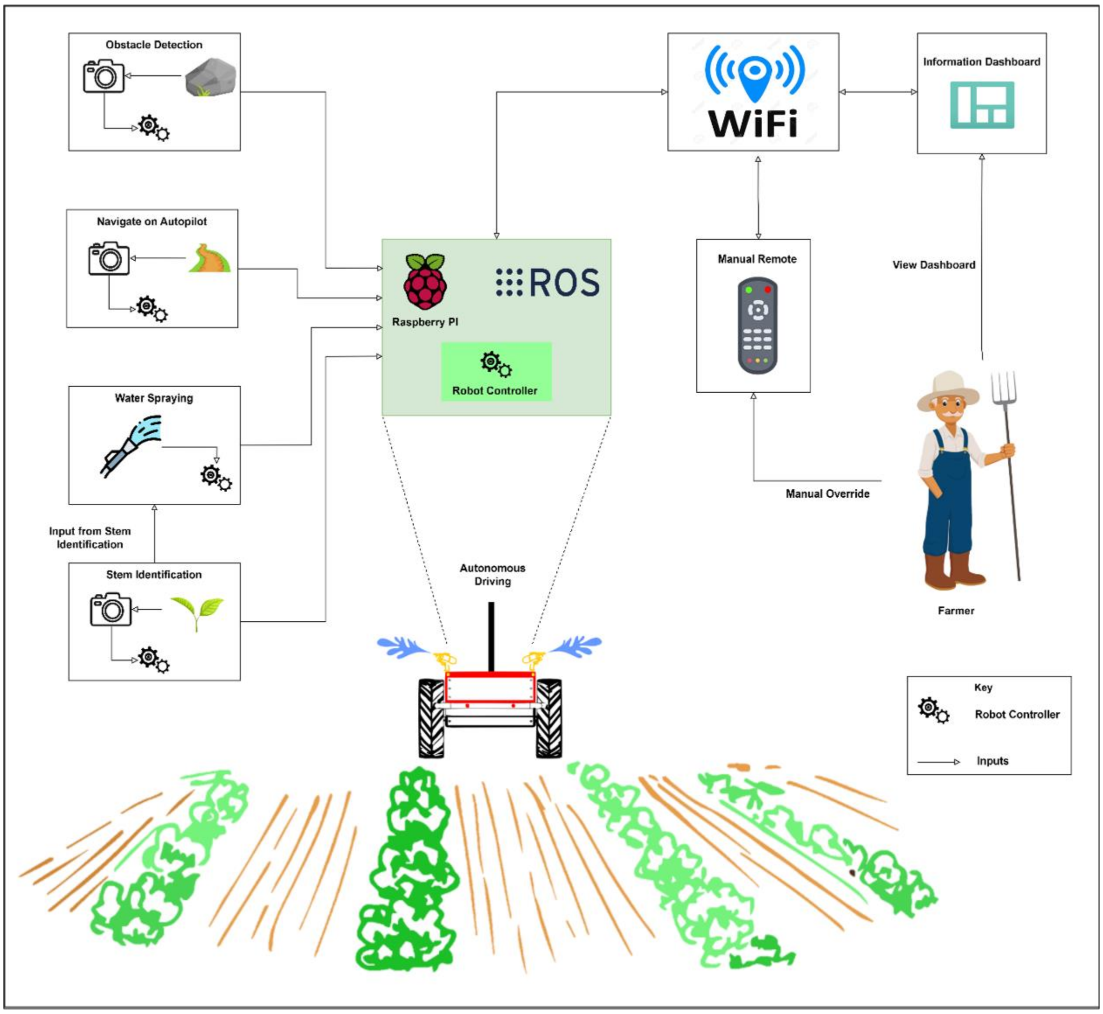

Figure 2-5: System Overview Diagram

2.2.2 Development of the robot controller (Autopilot)

The robot wheels are driving according to the given coordinates from the computer vision and sensor readings of the robot speed and the driving angle. The robot computer vision can identify the path between the tea plant rows. Then the robot can easily self-drive. Then change to another path and self-drive again. The robot will use PID controlling method to fine tune the navigation. (Figure 2-5)

2.2.3 Development of the robot controller (Manual)

A self-driving robot must have a manually controlled method to navigate the robot. If the administrator needs to drive the robot in a different path to go for another tea plants section or to drive when an emergency situation. The TeaBot is having a software application powered remote controller with the camera views to drive the robot manually. (Figure 2-5)

2.2.4 Hazard Identification

The robot is dragging the water hose and drive forward. If the hose is getting stuck on somewhere or if the robot will meet any disturbance on the road, the robot should immediately stop and notify the hazard to the administrator. If the robot is facing to a severe emergency situation, the robot controller will immediately disconnect the power supply and protect the hardware components. (Figure 2-5)

3 METHODOLOGY

TeaBot will be developed using the following methods to provide an effective product to the tea industry.

3.1 Requirement Analysis

By doing interviews and field visits to collect the current issues in tea plantation in the country. Gathered unsolved issues and found the most burdening problem is the lack of labor resources and the wastage of fertilizer and water. Gathered what are the needs for the plants, the land conditions, soil condition, ongoing progress of the crop and the expected crop if the plants having the best maintenance. Did a thorough survey on land condition and the least cost to make the road to drive the robot. Surveyed on the liquid fertilizing procedure and the soil condition during the dry and wet seasons. Then the gathered data was utilized to create the robot controller.

3.2 Feasibility Study

Most of the tea estates are having large scale lands (>= 1 acre). In some areas, the network connectivity is poor. Either the network is good or poor, the realtime computational operations of the TeaBot should feasible to do in a local computer. If need to send or receive data, it needs to use radio waves to send data in network poor areas. Since some land conditions are not feasible to make a network connectivity as it is not cost effective. In those areas, the roads to drive the robot are also poor. To make the roads perfect is not cost effective. So, the robot should feasible to drive on poor road conditions.

3.3 Implementation

The robot design is a combination of hardware and software.

3.3.1 Hardware

The robot chassis should be a rigid and a strong mechanical structure as the robot is driving on a off road condition. The dimensions of the chassis is 2 x 2 feet. The robot consists with an iron frame including four 8 inches wheels to maintain the body with a fixed height and a proper ground clearance and with a strong thread to reduce the wheels slipping on the soil. The complete weight of the chassis is 20kg to get the maximum friction force to drive on road. The all four wheels are powered by 12V motors and the front and rear wheels are parallelly connected left and right separated. Using all motor powered four wheels will increase the torque and the power of the robot to driving in off road conditions. The rear of the robot will carry the water hose. The motors and wheels are driving with sprocket and chain to maintain a proper gear ratio to increase the torque.

3.3.2 Software

The motors are driving with motor drivers. The motors need 10 amperes for each. The motor drivers can operate 43 amperes of power. Motor drivers are connected to the Raspberry Pi. The motors are driving with a 45 ampere battery and the Raspberry Pi operates with a 12v separate battery and a power regulator. The Robotics Operating System is using for the software operations. The all programs are doing with Python. The ROS uses separate nodes with the publisher subscriber on top of topics to send and receive data among other nodes. Then the Raspberry Pi will I2C to Arduino for the motor driving. The robot consists with motors cameras, pressure pumps and water nozzles. The all components are centralized by the Raspberry Pi. The Raspberry Pi can execute python libraries for the computer vision. The complete software runs as one package. Since a single package can easily deploy for new robots.

3.4 Work Breakdown Structure

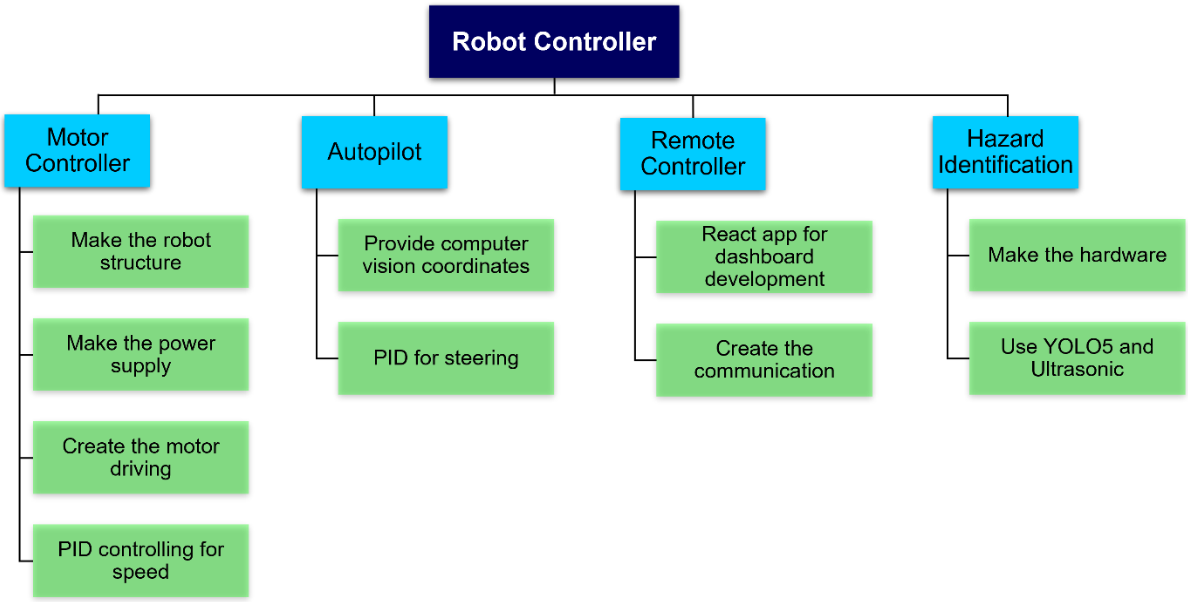

Figure 3-1: Work Breakdown Structure

3.5 Testing

Testing will be done at multiple stages.

1. Test the frame and motor-powered wheels on different terrains.
2. Test the forward, backward movements, and skid steering on different terrains.
3. Test the PID controlling and fine tune to go straight.
4. Test the power management, python coding with unit testings, test the speed controlling.
5. Combine the all components and test the robot on the tea field.

3.6 Gannt Chart

This proposing research is planned to carry out as follows to meet the required deadlines without any conflicts. Project implementation will be started in late March and expected to complete by mid-October while testing will be carried out from mid-October to end of November. The proposing research project will be completed by December 2023.

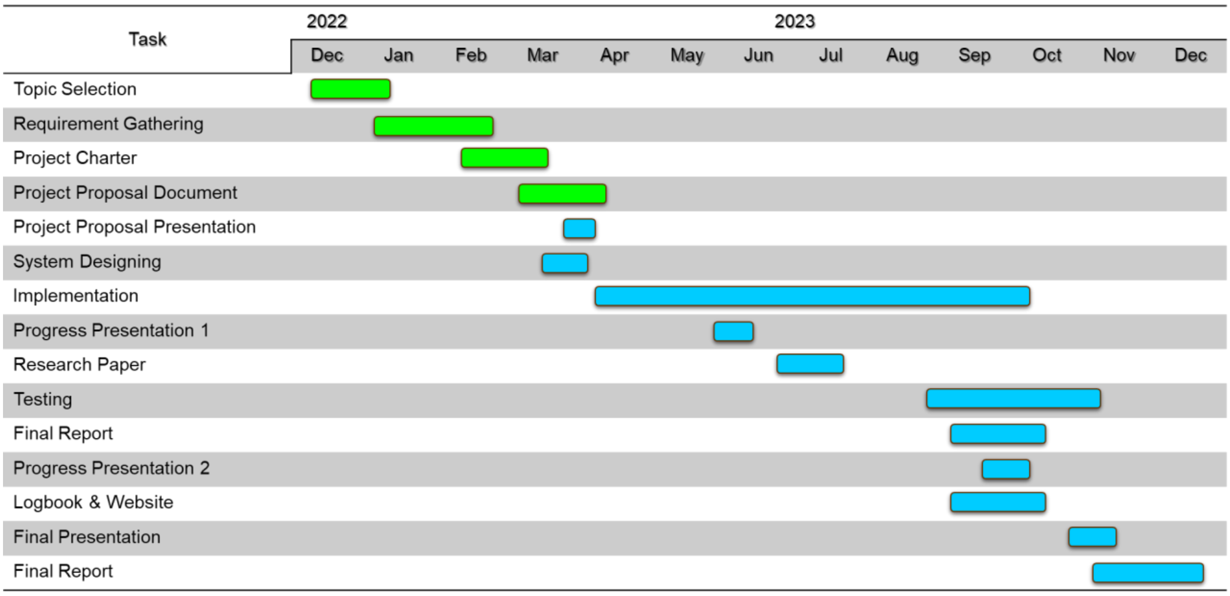

Figure 3-2: Gantt Chart

4 DESCRIPTION OF PERSONNEL & FACILITIES

Ms. Shashika Lokuliyana is the supervisor for this study. She conducts Information Security, Computer Systems and Networking, and Computer Systems Engineering as a Senior Lecturer. She is now employed with the Faculty of Computing, Sri Lanka Institute of Information Technology (SLIIT), Malabe, Sri Lanka, in the Information Systems Engineering Department.

Ms. Narmada Gamage is co-supervising for this project. She is an Assistant Lecturer in the Department of Information Systems Engineering, Faculty of Computing, Sri Lanka Institute of Information Technology (SLIIT), Malabe, Sri Lanka.

Mr. Rajitha de Silva external supervisor for this project. He is a PhD scholar of University of Lincoln, England, UK.

This research will be conducted by the following 4 members as shown below.

Gunawardana I.I.E – He is responsible for the research component of designing the robot chassis and developing the algorithm for the robot controller to navigate the robot.

Perera P.V.Y – She is responsible for the research component of developing the algorithm for the path detection, end of the path detection and provide the precised coordinates to the robot controller.

Premathilake H.T.M - She is responsible for the research component of developing the algorithm for the end of the tea stem detection and provide the precised coordinates to the liquid nozzles controller.

Bamunusinghe G.P - He is responsible for the research component of developing the algorithm for the liquid nozzles controller and navigate the nozzles more precise with the relative movement of the robot.

5 BUDGET & BUDGET JUSTIFICATION

Table 5-1: Estimated Budget

Item	Quantity	Amount(LKR)
Rubber wheels	4	4,000
Sprocket, chain and wheel (gear system)	4	10,800
Iron frame	1	15,500
Motors	4	14,000
43A Motor drivers	4	5,400
Raspberry Pi zero w	1	5,600
12V 45A battery	1	30,000
Camera	3	15,000
Liquid Nozzles	2	3,000
Servo motors	8	9,600
Total Estimated		**112,900.00**

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7 APPENDICES

7.1 Plagiarism Report

ORIGINALITY REPORT

4%	2%	3%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.sliit.lk Internet Source	1%
2	Submitted to Sri Lanka Institute of Information Technology Student Paper	1%
3	Submitted to Florida Polytechnic University Student Paper	1%
4	Min Hyuc Ko, Kyoung Chul Kim, Abhijit Suprem, N. Prem Mahalik, Boem Sahng Ryuh. "4WD mobile robot for autonomous steering using single camera based vision system", International Journal of Intelligent Unmanned Systems, 2014 Publication	<1%
5	inis.iaea.org Internet Source	<1%
6	"Improving Productivity through Automation and Computing", 2019 25th International Conference on Automation and Computing (ICAC), 2019 Publication	<1%
7	Jingyao Gai, Lirong Xiang, Lie Tang. "Using a depth camera for crop row detection and mapping for under-canopy navigation of agricultural robotic vehicle", Computers and Electronics in Agriculture, 2021 Publication	<1%
8	Shannmukha Naga Raju Vonteddu, PrasanthiKumari Nunna, P. Siva Subramanian, V Gopu, M. Nagarajan, G. Diwakar. "PID Controller based on BP Neural Network for Speed Control of Electric Vehicle", 2022 Sixth International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), 2022 Publication	<1%
9	coek.info Internet Source	<1%