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

TMP-23-044

Project Proposal Report

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

Department of Information Technology

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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
Bamunusingha G.P.	IT20011970	

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

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Signature of the supervisor

23/04/2023

Date

ABSTRACT

Crops are grown on a big scale in Sri Lanka. One of the most important export commodities that boosts Sri Lanka's GDP is tea production. In addition to other export commodities, tea has a long history, and Ceylon Tea is the most well-known brand worldwide. The world has a large market for Ceylon tea. The climate is mild, and the soil is fertile for growing tea in Sri Lanka. Because of this, Ceylon Tea has the same flavor that people in other nations adore. Sri Lanka had an abundance of people resources in previous decades to maintain expansive tea estates. As time passes, the nation is experiencing an industrial revolution. The population eventually began to disperse in search of new employment. Unlike other crops, tea requires proper maintenance and is more expensive. They were unable to keep up the tea estates as laborers declined. It affected to diminish the crops. Several estate owners began to switch to planting various crops with lower care costs. The export market was severely impacted. TeaBot is a highly developed autopilot robot that can irrigate and fertilize large-scale tea estates in place of human labor. The TeaBot is one of many robots that is specifically made to function in off-road environments without the requirement for well-defined, highly organized tracks. The robot primarily tends to the tea plants' watering and fertilization[1] needs. Because they require constant water and nutrients to produce the greatest crop, tea plants. The robot is improving productivity and reducing waste of fertilizer and water. The TeaBot can recognize the way to go, recognize the end of plant stems, and effectively water the plants.

Keywords – large-scale irrigation, Spraying, watering, fertilizing.

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LIST OF ABBREVIATIONS

PID	Proportional Integral Derivative
ROS	Robot Operating System
UI	User Interface
API	Application Programming Interface

1 INTRODUCTION

1.1 Background and Literature Survey

It has been challenging to maintain consistent irrigation and precise fertilization in massive plantations. Despite attempts to improve this process utilizing a number of different tactics, these efforts have fallen short as a result of issues like inefficient resource consumption, exorbitant pricing, and a labor shortage. The expense of hiring a huge crew is also much higher. Plantations cannot be accurately and timely watered or fertilized by hand, and in some situations, doing so is inefficient.

Most often, large-scale irrigation is not effectively monitored. If we contrast their effectiveness with small-scale production, it is also quite poor. Most countries perform big scale watering only by exploiting natural weather and rainfall seasons. In Sri Lanka, the wet season is used to cultivate plants, some of which are only native to certain areas. Although we can grow plants anywhere, large-scale plantations are only permitted in a few places due to environmental concerns.

There are a lot of factors to take into account before starting large-scale plantations in Sri Lanka.

1. **Climate**

Climate is defined as the condition of the atmosphere at a particular location over a long period of time (from one month to many millions of years, but generally 30 years).[2] These climate-related problems primarily affect regionalized and large-scale plantations. In Sri Lanka, there are primarily 4 climate seasons. Taking place in accordance with these climate seasons are large-scale plantations.

1. First Inter-monsoon Season (March - April)

   According to the distribution of rainfall over this time period, the hill country's entire south-western sector received 250 millimeters of rain, with some localized areas on the south-western slopes receiving more than 700 millimeters (Keragala 771 mm). Rainfall varied between 100 and 250 mm over much of the island, with the Northern Jaffna Peninsula being the only notable exception (Jaffna- 78 mm, Elephant pass- 83 mm).[2]

2. Southwest -monsoon Season (May - September)

   This season sees rainfall ranging from roughly 100 mm to over 3000 mm. The western slops' mid-elevations saw the most precipitation (Ginigathhena- 3267 mm, Watawala- 3252 mm, Norton- 3121 mm) [2]

3. Second Inter-monsoon Season (October-November)

   Almost the entire island receives in excess of 400 mm of rain during this season[2]

4. Northeast -monsoon Season (December - February)

   At this time, Kobonella Estate experiences the most rainfall (1281 mm), whereas Chilaw, a region along the Western Coast near Puttalam, experiences the least (177 mm).[2]

most of the Sri Lankan large scale plants grow according to these climate seasons. Because we can water, fertilize, and take care of the plants, small-scale plantations may operate in every season. Nevertheless, in larger-scale production, it is impossible to take accurate care of each and every plant.

2. Topography

The central section of the island is mountainous and has heights of over 2.5 kilometers, as well as complex topographical features such ridges, peaks, plateaus, basins, valleys, and escarpments. These areas' farmers cultivate crops using a range of methods. Apart from a few little hills that rise abruptly in the lowlands, the rest of the island is generally level. These locations experienced various effects of climate change because of their terrain.[2]

3. Temperature

Altitude, not latitude, is the primary factor influencing regional variations in air temperature over Sri Lanka. The seasonal movement of the sun has a substantial impact on the mean monthly temperatures, even after adjusting for rainfall. While temperatures in Sri Lanka's highlands substantially decrease, they are largely uniform throughout the country's lowlands. Up to a height of 100 to 150 meters, the mean annual temperature in the lowlands varied from

26.5 °C to 28.5 °C, with 27.5 °C as the average. As altitude rises, the highlands endure rapid temperature drops.[2]

In addition to these, a number of other elements are taken into account while farming on a large scale, but rainfall is the key one because it directly affects plant cultivation differentiation and growing seasons. The majority of Sri Lankan farming is done utilizing the rainfed system due to these rainfall effects. The rain and water reservoirs directly irrigate a variety of crops around the county.

PATTERNS OF CROP DIVERSIFICATION IN SRI LANKA

In the nation, crop diversification has taken place in a number of agro-ecological environments. This diversification occurs independently in various agro-ecological zones at various times, with varied motivational reasons depending on the environment. Below is a list of the main agro-ecological settings where crop diversification has been effective.[3]

a) Major Irrigation systems in the Low Country Dry Zone. [3]

b) Small-scale irrigation projects in the low country dry zone.[3]

c) Upland, middle, and lowland Anicut schemes and rice fields in intermediate zones.[3]

d) Rice fields in wetlands in low-lying, humid terrain.[3]

e) Mid-country – Slightly tea and rubber-producing areas.[3]

CROP PRODUCTION IN SRILANKA

This table displays crop production and their respective economic values.

Crop	Area 1,000 Ha	Production 1,000 Mt	Export 1,000 Mt	Imports 1,000 Mt
Tea	195	284	268	-
Rubber	159	97	43	-
Coconut	439	2808 mil nuts	916.48 mil nuts	-
Rice	781	2868	1.53	214
Sugar cane	7,976	399	-	479

Table 1.1: Comparison of former research related to exports.

[3]

From the above table we can identify One of Sri Lanka's most important exports and a major contributor to GDP is tea farming. Among other export crops, tea has a well-established history, and Ceylon Tea is the most popular beverage worldwide. The industrial revolution led to a decline in manpower for the tea plantations. The owners of the tea estates were unable to keep up the tea estates. So, it had an impact on the crops. Significant watering and fertilizing challenges exist on these tea farms. Traditional tea plantations use systems that are fed by the rain. Before it rains, fertilizer is applied to the plant's stem. These nutrients interact with the water after rain and are then ingested by the plants. These techniques are ineffective for tea plants.

It is useful and efficient to create an autopilot robot to irrigate and fertilize large-scale tea estates in place of human labor. The primary tasks performed by the robot are watering and fertilizing the tea plants. For the best production, tea plants require constant hydration and feeding. The robot is improving productivity and reducing waste of fertilizer and water. An automated irrigation system can be installed to overcome these problems[4].

Robots can accurately detect the plant stem during the watering process and deliver a precise dose of water and nutrients. This will cut down on both water waste and irrigation expenses. Each farmer can generate crops with this autopilot robot with or without rain. Using this technique, we can grow crops anywhere in the nation, even in the arid regions.

1.2 Research Gap

So, as was already indicated, there are many options available to enhance the watering and fertilizing of large-scale crops. The majority of automated systems are appropriate for plantations in greenhouses. There aren't many moving robots that can spray water precisely where the plants meet the ground. Also, the majority of robot systems lack a verifying device to determine whether water actually fell in the designated area. Most spraying systems waste lots of water and efficiency is low [9]. For tea plants, misting fertilizer is not recommended. Most of the systems do not have stabilizing water spraying nozzles. TeaBot will be able to precisely route the water nozzle component to the stem of the tea plant using the coordinates of the stem and the relative velocity of the robot with the watering arms.

Irrigation System	**Eligibility for tea field liquid fertilization**	**Watering scale**	**Issues**	**Mechanism**
Pressurized irrigation systems include sprinkler[5][6]	✗	Long	High cost	These systems spray pressurized water across the system and distribute water via pipelines.[5]
Solid set sprinkler systems[5][6]	✗	Long	Incorrect operating pressure reduce efficiency.[5]	Sprinklers are permanently fixed in well-designed solid set systems at spacings that produce the best consistency.[5]
Gun sprinkler systems[5][6]	✗	Very long	wind drift and evaporation losses lots of water.[5]	Large sprinklers known as "gun sprinklers" release water at high pressures and flow rates. [5]
Center pivot and lateral move systems[5][7][8]	✗	Medium	losses lots of water from the guns[5]	lateral move systems that increase the irrigated area by adding gun sprinklers to the extremities of the laterals [5]
Drip and line source systems[5][9]	✓	Short	High maintenance and	Apply water in tiny drops or streams from individual drip emitters to the soil's surface or just below it. [5]

			management cost	
Bubbler systems[5]	✓	Short	High maintenance and management cost	Using separate containers or basins, bubbler irrigation systems spray water around trees or other plants. [5]
Gravity flow irrigation Systems[5]	✓	Short	Losses of irrigation water due to lateral flow [5]	use gravity to irrigate[5]
Subirrigation systems[5]	✓	Short	Large installing cost and maintaining	A new water table is created over an existing one or one that is constrained by a layer of dirt. [5]
Surface (flood) irrigation Systems[5]	✓	Long	Large water wastage	water is distributed by flow across the soil surface[5]
TeaBot water spraying system	✓	Short	Solve lots of above-mentioned problems	water is fired from a sprinklers establish in robot

Table 1.2: Comparison of former research related to water spraying.

The TeaBot sprayer's capacity to navigate any terrain is the proposed solution. Compared to other systems, the cost is inexpensive, and maintenance is simple. Extremely little water is wasted, and there are no problems with the wind or wrong pressures. Spraying has a validation system and is accurate. If a pipeline system has a problem, it must check every pipeline to locate the exact location. In a TeaBot, checking the spraying arms makes finding problems quite simple.

1.3 Research Problem

Several research tests were conducted by some tea producers and researchers in an effort to create equipment that would allow them to irrigate and fertilize tea plantations while using fewer laborers. There are several irrigation techniques available, however the majority are not appropriate for tea. Most of them require large installment payments. A particular methodology will be used in this study challenge to close this gap. **How to create a spraying system that would effectively water and fertilize large-scale tea plantations** is the scientific challenge.

1. How to design the robot arm to control the water sprayers.
2. How to spray water to exact spot with the relative velocity of the robot.
3. How to build a stabilization mechanism in the sprayers reduce the shaking of the robot in off road conditions
4. How to build a system to track water spraying path and validate
5. How to regulate water pressure and, if water blocks occur, have the system turn itself off

2 OBJECTIVES

2.1 Main Objective

The TeaBot robot is suggested as a means of resolving the aforementioned issues. The development of the agricultural robot will focus on making it dependable and flexible so that the procedures of fertilizing and watering can be maintained. The TeaBot robot can also be described as flexible because it is capable of a variety of jobs. such as fertilizer to maintain soil fertility even during dry spells and irrigation to maintain growth and health. Water will be used during the fertilization process to increase efficiency.

Usually crops like tea and vegetables are grown according to a precise design. Like people, robots are able to recognize the rows of a plantation[10] in order to water and fertilize the appropriate plants. The robot will precisely detect the tea plantation rows and give the coordinates to the robot controller. With the coordinates of the stem the robot will be able to navigate the water nozzle component to the tea plants stem precisely with the relative motion of the robot with the watering arms. The camera is fixed to the platform and remains therefore fixed, regardless of the robotic arm’s movements[11].The watering will be done in stream of water not by spraying mist because spraying van harm the tea plant leaves when fertilizers added to the water. After watering it will be verified if the plants are watered correctly or not.

Watering nozzles should be V-shaped, with two sprayers on one side of the robot and the other two on the other side. To water rapidly and correctly, 4 sprayers must be managed collectively. The two nozzles on either side must alternately move from one plant to another. It also contains a number of valves[12] to regulate the water flow and lessen water waste. The arms include many weight control functions, and all 4 nozzles may move both vertically and horizontally.

The majority of water spraying devices lack a way to determine whether water actually reached the desired location. That is not correctly validating. Yet, TeaBot Robot has a unique mechanism to capture a laser light inside the parabolic water beam that is sprayed from the nozzle. Robots can detect the water path and ensure it properly reaches its target by employing side cameras. After that, it can inform the robot controller.

Also, it offers a variety of off-roading functions, such as the capacity to maintain power utilization and find risks using computer vision coordinates (Obstacles on the navigating road).

2.2 Specific Objectives

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

2.2.1 Development of the arm and hardware components

This is the most vital part of this proposed solution. Because this is the part it controls how the spraying nozzle moves and acts like a human hand. The arm of the sprayer is directly connected to water spraying nozzles. It may move to any side and shoot water in the direction specified by the coordinates. This has a total of 4 arms with identical hardware features. These dynamic arms can connect to any side of the robot and are flexible. The robot can be equipped with a variety of arms that can carry a range of weights depending on the various farming fields. These arms have the ability to control the pressure, spraying distance, and height in accordance with the field. The water spraying mechanisms on the robot arm must also be stabilized because the robot moves in off-road environments and its equipment can tremble at any time.

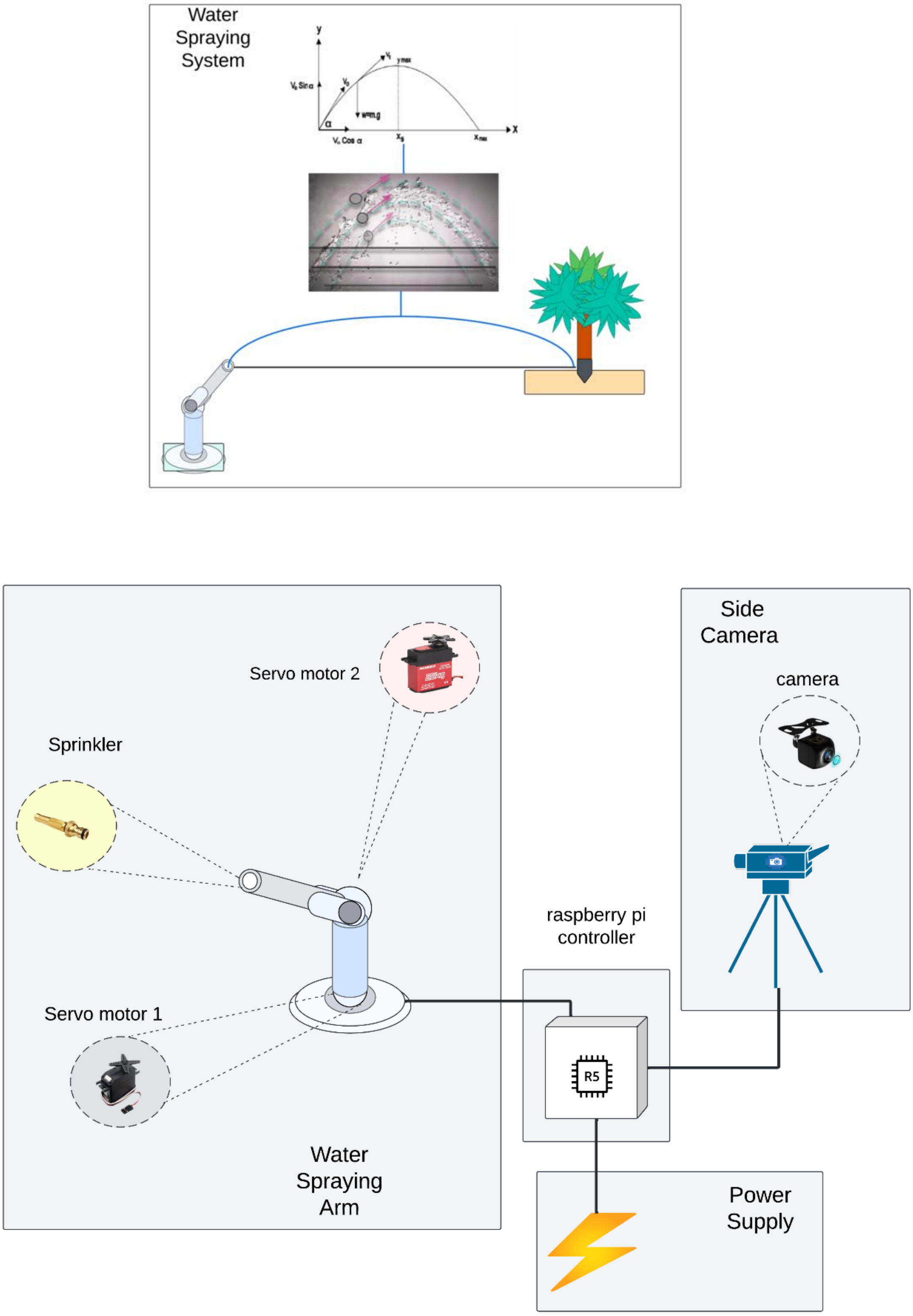

Figure 2.1:Development of arm and hardware parts

2.2.2 Development of the algorithm and software components

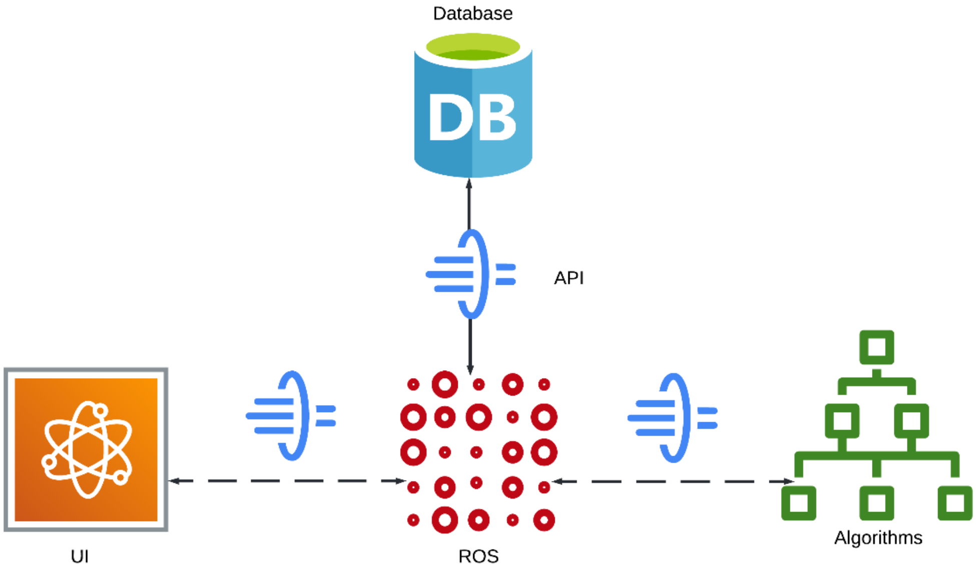

Figure 2.2:Development of the algorithm and software

The primary area of research for the water spraying system is in this section. Servo motors, valves[12], and other mechanical components of the arm must be moved using the Python programming language. Nonetheless, every movement must be carried out in accordance with an algorithm. This algorithm should include multiple variables. the robot's speed, the density of the water mixture, the distance from the spraying nozzle to the stem, and the water pressure. The aforementioned variables are mostly calculated using physics, and in accordance with these results, the angle of the arm and the water pressure need to be adjusted in order to fire water onto the stems of the trees. The PID algorithm [13] also applied to stabilize the spraying nozzles of the Robot.

2.2.3 Laser light tracking mechanism.

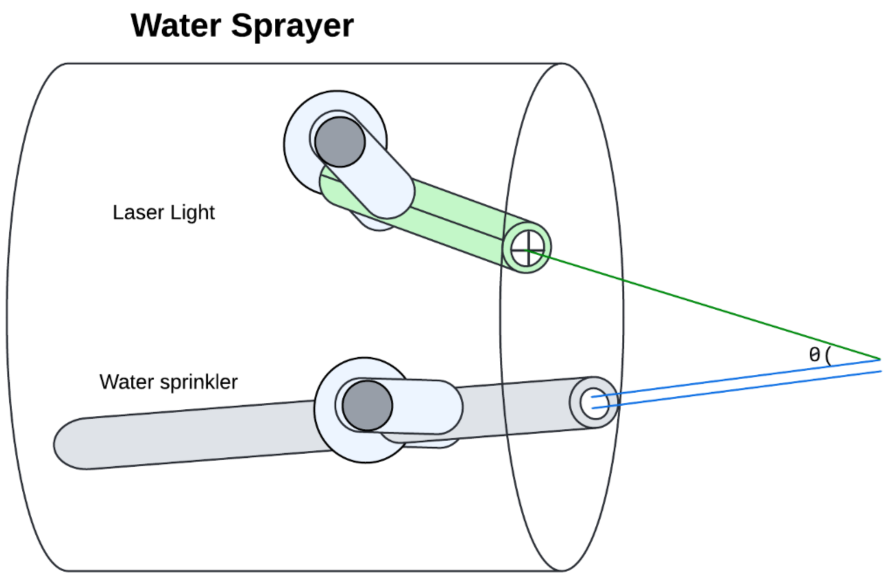

Figure 2.3:Water Sprayer

The first water tracking system utilized for a robot spray validation system is this laser light system. Water has a parabolic shape and behaves like an optical fiber. Laser light is adjusted in accordance with the angle at which the water sprays. Water has a reflective index, which may be somewhat greater with the fertilization mixture than natural water. A laser beam with a projected power of about 49^0 will internally reflect[14] inside the water and become trapped there. In comparison to conventional spraying systems, employing the side cameras to trace the water's course and make decisions results in more accurate results.

3 METHODOLOGY

TeaBot, the proposed watering solution, would be developed in the following ways to deliver an efficient solution for large scale farmers.

3.1 Requirement Analysis

Farmers that operate in locations with extensive farming provided the majority of the analyses for this study. Their domain knowledge and requirements for a large-scale irrigation solution in their farms were shared over one-on-one phone conversations and online chat platforms. To build a lasting solution for the objectives and goals that this provided for big scale watering system, the collected data was used to discover and investigate unmet needs, unsolved difficulties, and potential improvements in large scale farming[15].

- Functional Requirements
  - Water spraying to the stem.
  - Rotation of the water arm.
  - Water spraying angle control.
  - Water pressure control
- Non-Functional Requirements
  - Accuracy
  - Performance
  - Speed
  - Reusability
- System Requirements
  - Computational power to run the algorithm.
  - Continuous water flow
  - Rotation angles of the motor

- Personal Requirements
    - Farmers
    - Tea State owners
    - Agriculture field experts

3.2 Feasibility Study

The TeaBot, the ultimate product described in this proposal paper, will integrate software algorithms, cloud computing, machine learning, and electronics. So, the members must be technically capable of using the technologies and completing the product's development to the specified elements in order to build the product in accordance with the aforementioned standards.

3.3 Implementation

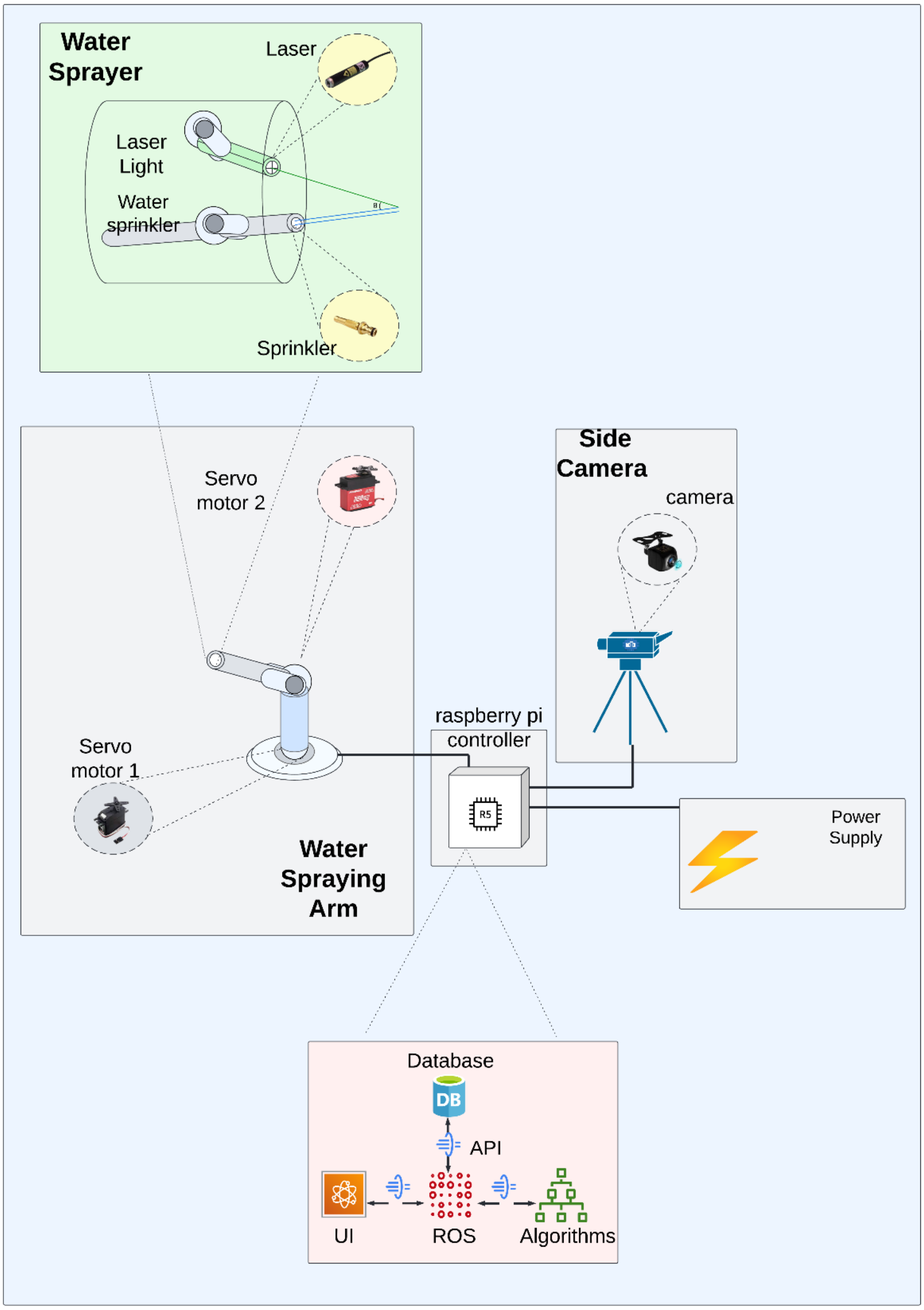

Figure 3.1: System overview diagram

The TeaBot's watering system is built using the most recent hardware and software. The four watering arms can be changed to fit different farming fields and share the same hardware functionality. The water spraying arm contains 180^0 liftable and 360^0 rotating motors. Power connections are attached to the battery used for the robot controlling feature, and an Arduino controller is mostly used to drive these motors. This 45Am 12V battery powers the entire robot-controlling system. If the current drawn by the motors is too great, the current must be reduced using a certain type of resistor. The weight of the arm and the weight of pipes including water determines which of these servo motors should be used, and each servo motor has a unique power supply need. A pressure monitoring system[16] is also necessary for water spraying from the nozzle to the stem. Water pressure decreases as the robot moves from one end to the other, so a pressure pump must be added to the system to maintain the pressure level precisely.

Solid works is used to design the robot arm and Python is used to control the electronic parts of the arm. The primary robot controller is a Raspberry Pi, device running Ubuntu Controller. This controller mostly uses the ROS framework[17] as a set of middleware. The other functions are all linked to this ROS system and communicate with one another. Many readings are necessary to spray water. Speed metrics are obtained from the accelerometer, distance parameters from the machine learning component, and the robot's tilting angle while traveling are gathered through the gyroscope sensor.

Each water shooting mechanism contains adjustable spraying nozzle as well as laser light. According to the overall reflection angle of the water mixture, this laser light needs to be fixed to the water spraying nozzle. As a result, the laser and water will become stuck inside the spraying route, and side cameras with machine learning algorithms can precisely track the shining water beam points. If the water beam does not spray precisely, it must be repeated in the same location. If the parabolic water spraying nozzle is malfunctioning, the system will alert the user.

3.4 Work Breakdown Structure

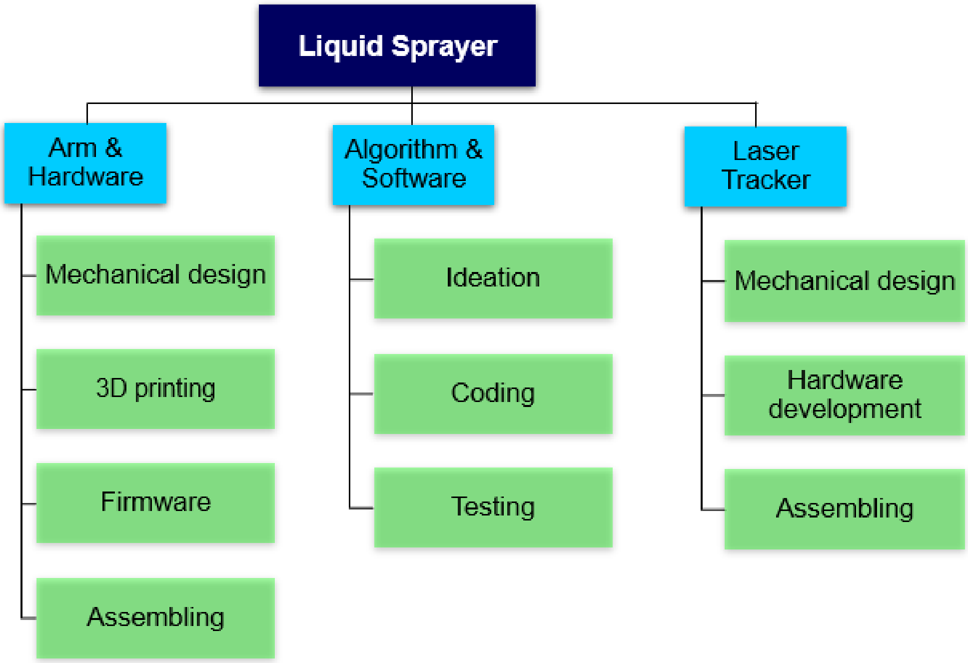

Figure 3.2:Work Breakdown Structure

3.5 Testing

Verify that the system's subcomponent is operating correctly. Throughout the development process, this will be done concurrently. This will be done to find bugs in the system as the functionalities are implemented. Here, testing will be carried out on the Arduino model to ensure that it produces the desired results. Examples include test cases for mathematical algorithms to ensure that it produces the right results for the input results and properly classifies the problem. Ensure sure the algorithm functions flawlessly and produces the right results in off-road scenarios.

3.6 Gannt Chart

This proposed research is planned to be carried out as follows to meet the required deadlines.

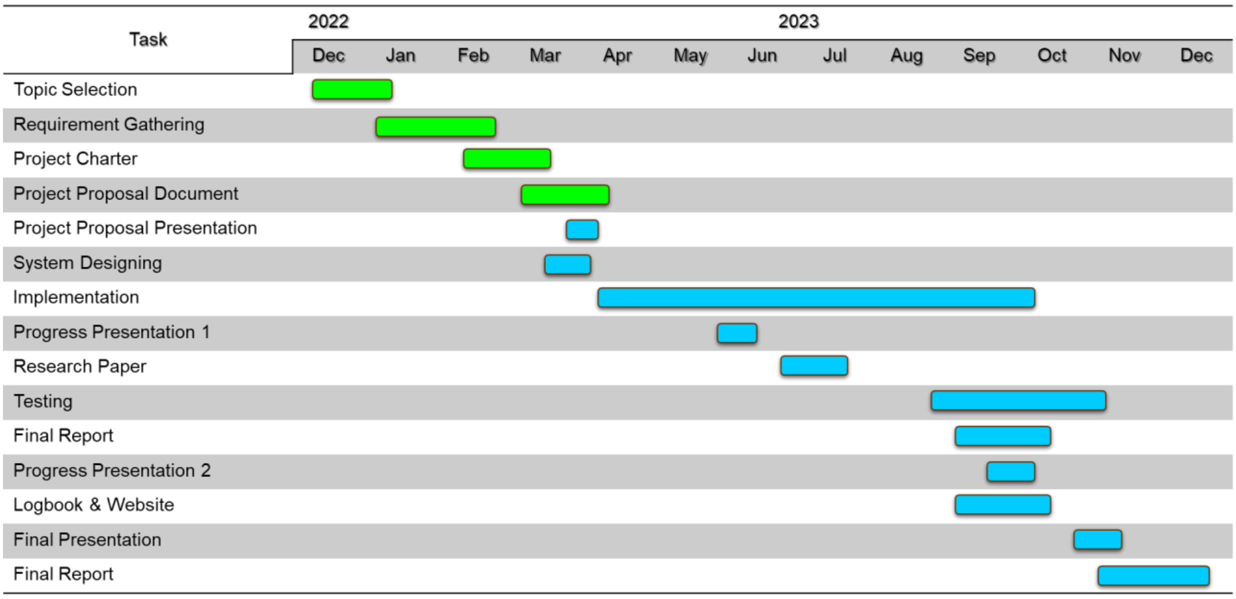

Figure 3.3:Gannt chart

without any conflicts. Project implementation will be started in late February and expected to be completed by mid-September while testing will be carried out from mid-August to end of October. The proposed research project will be completed by December 2023.

4 DESCRIPTION OF PERSONNEL & FACILITIES

Ms Shashika Lokuliyana is in charge of this study. She teaches 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.

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

Mr. Rajitha de Silva joins this research as the external supervisor. He is a PhD scholar of University of Lincoln, England, UK.

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

1. Gunawardana I.I.E – He is responsible for the develop an algorithm for the robot controller to navigate the robot with the coordinates given by the computer vision and identify hazards. This includes,
    a. Creating the robot chassis and the mechanical parts.
    b. Creating the PID (Proportional Integral Derivative) controller to navigate the robot.
    c. Identify the background hazards using object detection algorithms.
    d. Creating the manual controller for the robot.

2. Bamunusinghe G.P – He is responsible to develop an algorithm to operate the water spraying function in real-time with respect to the relative movement of the robot. This includes,
    a. Creating the hardware mechanism for water spraying.
    b. Tuning the water spray motors according to the robot's motion.
    c. Spraying water to the plants according to the relative velocity of the robot by using the 4 nozzles (nozzles will be controlled with stepper motors) to the groups of plants.
    d. Implement the tracking system to validate water spraying path.

3. Premathilake H. T. M – She is responsible to develop an algorithm to precisely identify the end of the stem. These include,
    a. Initially identify the data requirements.
    b. Develop the machine learning algorithm to precisely detect the end of the stem of the tea plant.
    c. Train the machine-learning model.
    d. Testing the model.
    e. Optimize the model.

4. Perera P.V.Y M – She is responsible to develop an algorithm to detect the tea plantation rows more accurately for the navigation of the robot, deciding the end of the path, and the signs.

a. Creation of the dataset
b. Developing the machine learning model to detect crop rows more accurately in various environmental conditions.
c. Training the model to detect the crop rows.
d. Testing the model.
e. Optimizing the model

5 BUDGET & BUDGET JUSTIFICATION

Item	Amount(LKR)
Servo Motor * 8	9600.00
Sprinkler	5000.00
Laser light	4350.00
Arduino nano	3000.00
Aluminum	3000.00
Total Estimated	**24,950.00**

Table 5.1: Estimated Budget

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7 APPENDICES

7.1 Plagiarism Report

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