Lawn Mower Robot

Requirements Specification Document

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1. The Purpose of the Project:

To build a smart automated Robotic Lawn Mower, which will be a hit in current Market scenarios. Customers, who don't like or don't have the time to maintain their lawns, this automatic mower will be a relief for them. It will be very easy to operate and will be well connected to the Home Network securely.

1.1. System development and System Periphery:

- The boundary will be marked by company's service personnel.
- Although the mower will be autonomous, a bit manual controlling through app will be allowed.
- The camera, charging station and everything in a local network will be installed by the company's representative as well.
- Any gadget, with a browser and connected in the same local network, will be able to control the bot.

1.2. User Interface:

Figure 1: Console UI template

- The UI will be minimal and easy to use. Scheduling option will be added. The language can be switched on a click of a button.
- This console can be accessed through any device with a Web Browser within the same network, irrespective of the Operating System.

2. The Client, the Customer, and Other Stakeholders

2a. The client: The customer is the professor.

2b. Other Stakeholders

- Sponsor – Professor
- Technology experts, system designers and testers – students

3. Users of the Product

- This is fictitious product intended just for education and learning.

4. Mandated constraints

- The robot must be built with the provided components and there is an additional constraint of €20 to buy additional components.
- It should be developed by end of June, 2021.
- It should be smart enough to avoid obstacles.
- It should be connected to the digital environment.
- It should be able to go to the charging station autonomously as well.

5. Naming Conventions and Definitions

- PEP8 guidelines will be followed in all python codes.

6. Relevant Facts and Assumptions

- All shapes if lawn can be mowed.
- Also, the area is considered without any inclination.

7. The Scope of the Work

Based on the inputs given by the Professor, we have defined the basic functional requirements of the product.

- The mower is self-navigating robot, randomly within its boundary.
- The machine can be started manually or self-starting as per the timer. The Robot is continuously powered and moves upon user intervention. The User can operate the mower using the switch on the mower or the mobile application.

- An onboard power switch for manual Start/Stop.
- HMI for showing the status of the machine while in operation. An LCD array will be used to show the Robot status. The Web app will also show its status.
- It should return to the station on low battery.

8. The Scope of the Product

- Easy to use product.
- Easy administration, one-touch operation.
- Battery supervision and Management.

9. Functional and Data Requirements:

9.1. Requirement: Navigation

- Technical solution: Random mowing
- The technical solution we are providing for navigation is random mowing. The mower robot will follow a random pattern and it will cover the entire arena. After an obstacle is detected, robot will rotate and start mowing again in a straight line fashion. Hence the main events that occurring are:
- Moving forward and backward
- Taking turn (left or right)
- Detecting and avoiding obstacles
- Detecting boundaries

  Moving forward, backward and taking turn:

  For the duty cycles of the motors is limited, so that they rotate simultaneously.

  Detecting and avoiding obstacles:

  Robot can detect the obstacle using Ultrasonic sensor. Once detected, it rotates 120 deg towards right, then continues travelling.

  Open issue:

  Without a predetermined size of the obstacle, it'll be difficult to maneuver the robot around it.

  Detecting boundaries:

  IR sensors will be used to detect boundaries which are

  Overcoming Slope:

The approach of detecting slope and then overcoming slope is mostly similar to the approach used in above case. If the values of the feedback PWM signal of both motors are less than the nominal value. Then slope is detected. We can overcome slope by slightly increasing duty cycle of PWM signals which is sent to both the motors.

9.2. Requirement: Operating robot with mobile phone

- The main components that are involved in this operation are ESP32 and mobile phone. Manually starting mower process with mobile phone: This can be done by clicking start button that is available on the web browser on mobile. Then ESP32 will run the mower according to the predetermined set time and date of mowing autonomously. The current time is synced using utime libraries in Micropython. The robot can be stopped similarly as well.
- Assumption: The router to which ESP32 should have internet access, so that we will be able to get real time clock information which we will use for scheduling.
- Similarly, robot can also be stopped by clicking stop button on web browser. Emergency stop button present on web browser helps to abruptly stop the machine.

9.3 Requirement: Operating robot with on-board switches

- Three switches are present on-board. They are start, stop switches. By clicking these switches, we can operate the robot accordingly. Emergency stop button would stop the robot abruptly.

9.4 Requirement: Going back to charging station when battery is low

- If the battery life detected is less than 20% of the whole capacity of the battery, then low battery mode is triggered. In low battery mode, blades will stop rotating and the robot will find the boundary, and then move along it to reach the station.

10. Look and Feel Requirements

- Attractive and appealing for variety of people.
- The mobile application should have an attractive User-friendly Interface.

11. Usability and Humanity Requirements

- The mowing strategy will guarantee that the minimum area is covered.
- Battery Choice: In one full charge of the battery, the entire area should be mowed.

- Operation language can be changed according to user preference. In built translator can be provided as an add-in.

12. Performance Requirements

12.1. Reliability and Availability Requirements

- The product being a prototype that uses a battery for mowing operation, the product runs for as long as the battery lasts.

12.2. Robustness or Fault-Tolerance Requirements

- The product immediately stops working after it loses it connection with the Network.

13. Operational and Environmental Requirements

- The mower should overcome obstacles with a height of 1 cm.
- The mower should overcome a slope 20% or less.
- The mower should operate only within the Boundary area.

14. Maintainability & support requirements

- Battery shall be changed manually once it reaches predetermined charging station in mowing area.
- The mowing knives shall be changed manually.
- Robot wheels needs to be cleaned manually.

15. Security Requirements

- The Robot Mower will be protected from unauthorised usage. It can only be accessed by those who have the Wi-Fi credentials.
- The data is fully secured to the user's device and not stored on any external server for the purpose of utmost safety.
- Robot mower, when picked up, stops working and notifies the owner that it has been picked up.

16. Cultural and Political Requirements

- The project would not of course have any cultural and political obligations.

17. Legal Requirements

- The compliance should be done under the valid rules if systems security.
- It should not infringe any patents.

18. Open Issues

- The product lacks the versatility of covering a variety of terrain effectively.
- Accuracy of Object Detection and Avoidance.

19. Tasks

19.1. Planning of the Development Phases

Phases	Work	Start	End	Status
Requirement Phase	Reading Lastenheft	18-Apr-2021	18-Apr-2021	Done
	Preparing specification Document	25-Apr-2021	03-May-2021	Done
Design Phase	Assembling the kit	25-Apr-2021	28-Apr-2021	Done
	Preparing the circuit Layout	26-Apr-2021	07-May-2021	Done
	Choosing the sensors	20-Apr-2021	07-May-2021	Done
Software development phase	Learning Micropython and OpenCV	06-Apr-2021	20-Apr-2021	Done
	Test individual sensors	26-Apr-2021		Working
System testing phase	Start testing for different Scenarios	20-May-2021		Working
Launch				Yet to start

20. Risks

- **Malfunctioning of components:**
  As the rotating blade can be harmful, malfunctioning of any component is strictly undesirable.

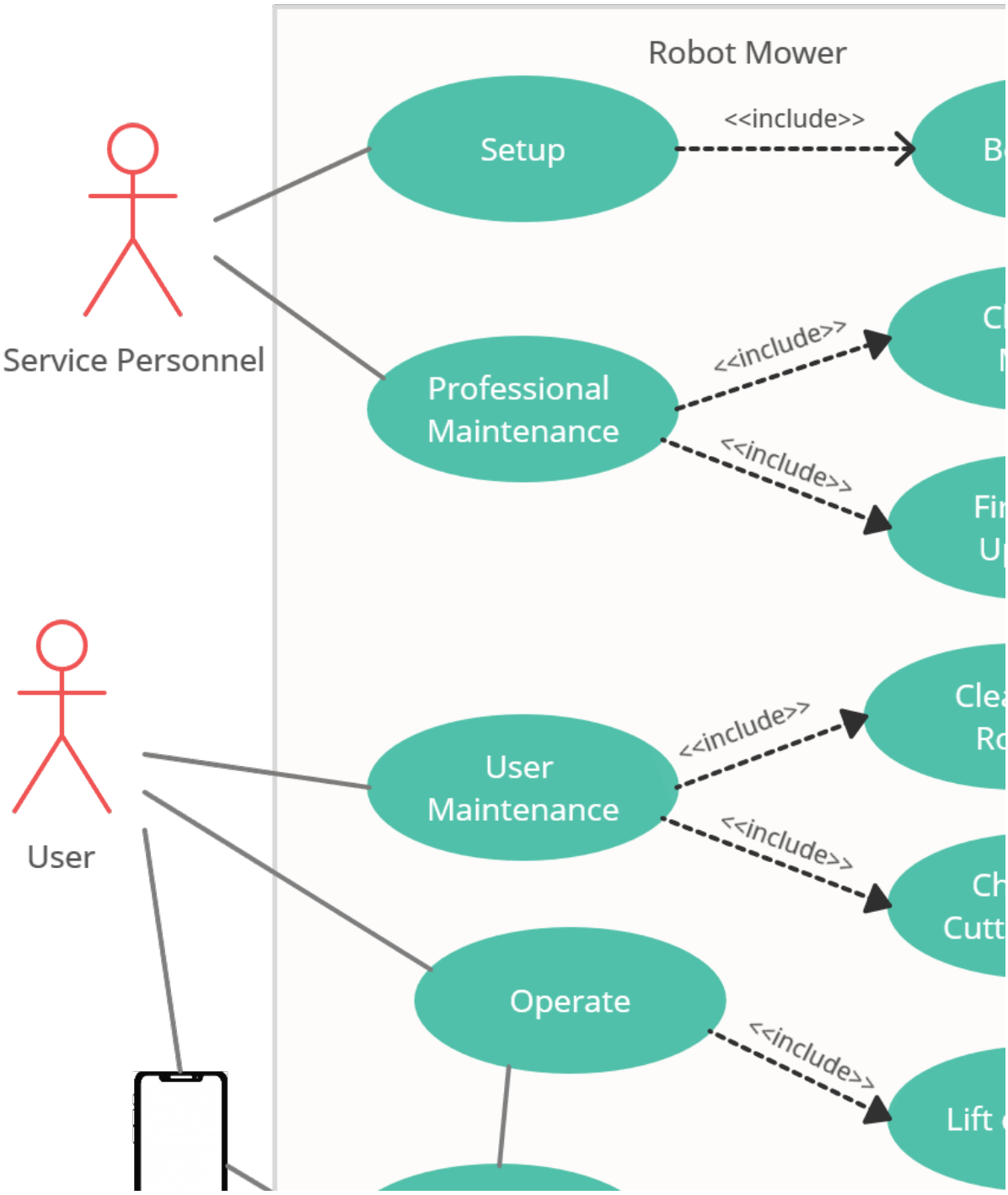
21. Costs

- Professor being the customer, sponsors for the "DIY Robot kit". An additional amount of 20 euro can be reimbursed if additional components required for the project are purchased.

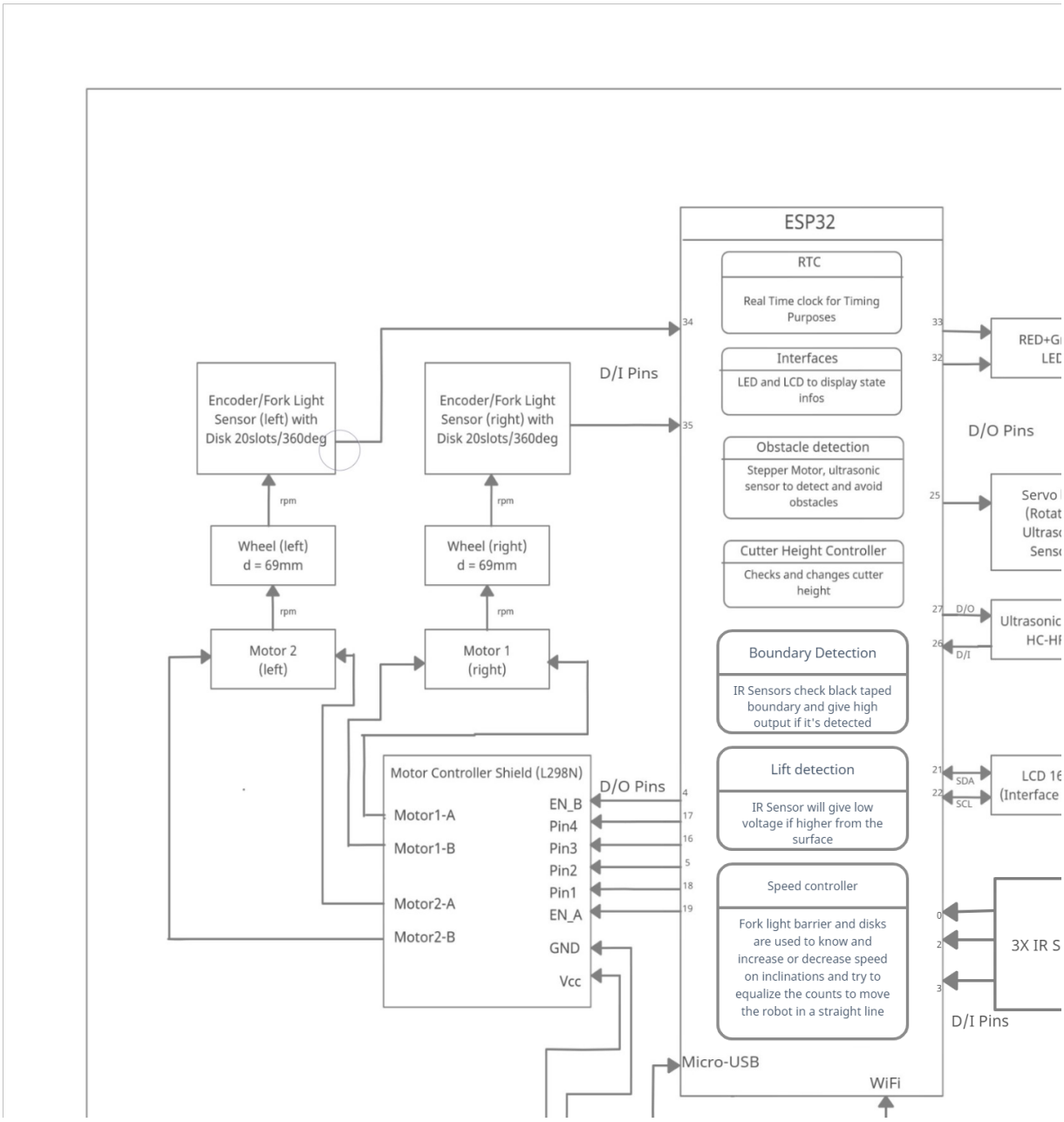
Components	**Quantity**	**Approx. Cost (Euros)**
Black Tape	1	1
Micro USB cable	1	--
Glue Gun	1	3
DST	1	3
Power bank	1	10
IR sensor	3	5
Breadboard	1	--
LCD display(I2C)	1	8
Push buttons and switches	2	--

- Additional components may be required in addition to above mentioned list.

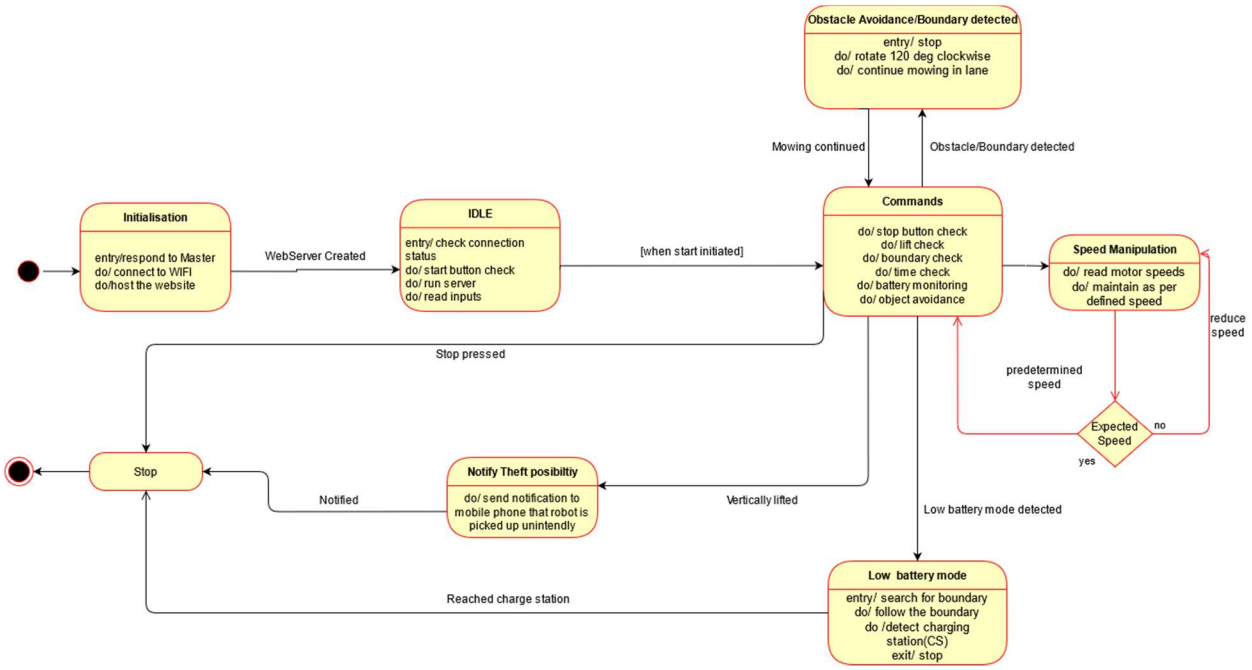
22. Use Case Diagram



23. Block definition diagram



24. State machine diagram



25. FMEA Analysis

Severity	Classification	CONSEQUENCES: Safety	Equipment/ Maintenance Cost	Production	Environmental	PROBAB: 1	2	3
						< 1%	1% - 5%	5% -
						Remote	Extremely Unlikely	Ver Unlik
5	Disastrous	Multiple fatalities, > 5. Large effects on large external inhabited zones- several fatalities	Extensive damage >$8M	Major loss, not recoverable. More than 3 days lost production	Major pollution with sustained environmental consequences external to the site	5	10	15
4	Catastrophic	Lethal effect on several persons (several fatalities). Lethal external effect - one fatality, several physical injuries	Major damage $6M-$8M	Major loss. Up to 50% not recoverable Up to 3 days lost production.	Major pollution external to the site. Evacuation of persons	4	8	12
3	Major	Lethal effect on one person and/or several permanent invalidities. Permanent external effects	Localized damage $2M - $6M	Medium loss, not wholly recoverable through normal production < 24 hours lost production	Moderate pollution, within site limits. Product liability	3	6	9
2	Serious	Permanent injury, lost time accident. Non-permanent external effects	Minor damage $200K - $2M	Minor loss, recoverable through normal production 2 to 8 hours lost production	Spill or release of pollutant requiring a declaration to authorities but without	2	4	6

A risk analysis has been done in the below table base on the above table.

ID	Risk description	Likelihood of the risk occuring	Consequences if the risk occurs	Overall risk	Mitigation action
1	Budget risk	Moderate	Moderate	Moderate risk	Layout of Pins and sensors as early as possible and as preciese as possible
2	Lack of knowledge	Likely	Significant	High risk	Start early woth research to detect potential lack early
3	Schedule risk	Almost Certain	Significant	Extreme risk	Prioritize project goals; periodically team meetings about actual status
4	Integration incompatibility of different hard- and/or software parts	Unlikely	Significant	Moderate risk	Lookup compatibility of each devices and try to do tests of different groups early
5	Regulatory risk	Almost Certain	Minor	Moderate risk	Trying to avoid patent and norm violations
6	Design risk	Unlikely	Moderate	Low risk	Keep the planning and requirement document very close to the "Lastenheft"

26. Appendix

- The product has been named as SAM – Schedulable Autonomous Mower.
- Its design, features and colours are finalised.
- Instead of only ESP32 as the main motor controller, Arduino Uno has been added to the circuitry and ESP32 will act as a NodeMCU.
- LCD from the Mower is removed and LED notifications are added. But still the current Mower status can be seen through the WebServer.
- Along with fulfilment of all the other specified requirements, the Mower robot is capable to check current weather status and act accordingly. For example, if it's raining or snowing, the mower robot won't leave the charging station and as well as return to it.
- The mower can now be manually started or stopped through the webserver itself.