LawnGenie
AUTOMATED GRASS CUTTING ROBOT

Capstone Project Report

MID-SEMESTER EVALUATION

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ABSTRACT

The rapid growth of various high-tech tools and equipment has made our jobs quite comfortable and sophisticated. There has been an exponential increase in autonomous systems and devices in our daily lives. The drastic increase in fuel cost and the effect of the emission of hazardous gases from burnt fuel into the atmosphere urges the use of abundant solar energy from the sun as a power source.

This project aims at fabricating an automated grass-cutting machine system which is an improvement from the ones already available in the market.

This grass cutter prototype does not only use renewable sources of energy like solar energy for its working but also reduces air pollutants and is an improvement from the currently available design. Our system will relieve the consumer from mowing their lawns and help reduce environmental and noise pollution. This design is an alternate green option to the popular and environmentally hazardous gas-powered lawn mower.

Ultimately, the consumer will do more for the environment while doing less work in their daily lives.

DECLARATION

We hereby declare that the design principles and working prototype model of the project entitled LawnGenie – Automated Grass Cutting Robot is an authentic record of our own work carried out in the Computer Science and Engineering Department, TIET, Patiala, under the guidance of Dr. Neeraj Kumar during 7th semester (2023).

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Lastly, we would also like to thank our families for their unyielding love and encouragement. They always wanted the best for us, and we admire their determination and sacrifice.

Date: 26 August 2023

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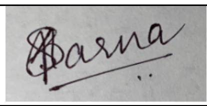
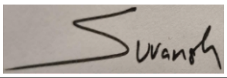
102016091	APARNA SOOD	
102017118	SUVANSH SHARMA	
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LIST OF ABBREVIATIONS

SLAM	Simultaneous Localization and Mapping
YOLO	You Only Look Once
LDR	Light Dependent Resistor
LIDAR	Light Detection and Ranging
DC	Direct Current
IOU	Intersection Over Union
APL	Applied Physics Laboratory
UHF	Ultrahigh Frequency
DSP	Digital Signal Processor

INTRODUCTION

1.1 Project Overview

In recent years, automation has become an integral facet of our lives, driving technological progress and overall development. As people increasingly seek ways to simplify their daily routines and minimize the drudgery of mundane tasks, the demand for innovative solutions has surged.

Maintaining vibrant and verdant lawns presents a notable challenge that absorbs substantial time and effort, particularly in regions with robust grass growth. This incessant need for mowing is exacerbated in warmer climates where grass requires frequent trims. For farmers and garden enthusiasts grappling with the ceaseless cycle of grass cutting and weed removal, the introduction of a robotic assistant holds undeniable appeal.

Enter LawnGenie, our groundbreaking concept that encapsulates an entirely automated robot capable of deftly managing repetitive and time-consuming chores. By effectively relieving individuals of such laborious duties, LawnGenie not only liberates valuable time but also empowers human resources to redirect their energies towards innovation, product development, and higher-order tasks.

LawnGenie distinguishes itself through its ingenious incorporation of solar power, a departure from the conventional energy sources underpinning other lawnmowers. Solar energy stands as one of the swiftest-growing electricity technologies, fueled by technological evolution, cost dynamics, favorable policies, and progressive regulatory frameworks. This clean and renewable energy source aligns with the movement towards more sustainable and eco-friendly energy systems.

What sets LawnGenie even further apart is its integrated drip irrigation system and seed dispenser. This innovative addition takes lawn care to new heights by addressing the crucial needs of watering and seeding. Through a thoughtfully designed drip irrigation mechanism, LawnGenie can provide precise and efficient watering to promote optimal grass health. Simultaneously, the built-in seed dispenser facilitates convenient and strategic seeding, bolstering the growth and rejuvenation of the lawn.

Moreover, the operation of LawnGenie yields zero greenhouse gas emissions, thereby contributing substantively to the global initiative to combat climate change. This environmentally conscious approach not only aligns with responsible living but also underscores the potential for impactful change through collective actions, no matter how modest they may seem.

At its core, the fundamental objective of LawnGenie remains rooted in offering an intelligent alternative to conventional mowers. As the era of automation dawns upon us, LawnGenie symbolizes our initiation into a new epoch of comprehensive automation – bridging the past with a future characterized by ingenuity, sustainability, and enhanced quality of life.

FIGURE 1: Types of lawn mowers

However, as consumers become more environmentally conscious day by day, they are searching for ways to lessen their individual carbon footprints. According to the Government of Canada, a gasoline-powered lawn mower emits about 48 kilograms (106 lbs) of greenhouse gas in one season. Running an older gasoline-powered lawn mower for one hour can produce as much air pollution as driving a new car 550 kilometres. [2]

This leads to the need to create a system that is not only technologically advanced but also ecofriendly and a viable option for all.

FIGURE 2: Pollution caused by Gasoline-powered Lawn mowers

The encroachment of technology and smart hardware into our daily lives has reached a point where it's becoming integral to nearly every facet of our routines. These systems share a common objective: to streamline our lives and enhance their manageability.

In the case of LawnGenie, we're embarking on a journey to develop a solution that not only simplifies our lives but also contributes to a greener and cleaner future.

LawnGenie, our automated grass-cutting robot, embodies a fusion of sophisticated hardware design strategies and highly precise artificial intelligence and machine learning principles, resulting in a state-of-the-art apparatus. This endeavor strives to yield a system that's not only affordable and user-friendly but also rich in features and cost-effective. With LawnGenie, our goal is to expand upon the existing capabilities while simultaneously driving down costs to the lowest feasible levels.

1.2 Need Analysis

Automation has seamlessly integrated itself into the tapestry of our lives, propelling technological breakthroughs and holistic advancement in recent times. As people increasingly yearn for ways to streamline their routines and truncate the time spent on mundane tasks, the pursuit of innovative solutions has grown fervent.

Sustaining vibrant and verdant lawns presents an enduring challenge that consumes considerable time and labor, particularly in warmer climates where swift grass growth necessitates frequent mowing. For farmers grappling with the ceaseless cycle of grass cutting and weed removal, the advent of a robotic collaborator holds immense allure.

Enter LawnGenie, our revolutionary concept that encapsulates a fully automated robot adept at orchestrating repetitive and time-intensive tasks. By relieving individuals of such laborious undertakings, LawnGenie not only reclaims valuable time but also empowers human resources to pivot toward innovation, product development, and more value-added pursuits.

LawnGenie's distinctiveness springs from its innovative harnessing of solar power, distinguishing it from conventional lawnmowers reliant on traditional energy sources. Solar energy has burgeoned into a swiftly burgeoning electricity technology. The interplay of technological evolution, cost dynamics, supportive policies, and regulatory frameworks has propelled the ascendancy of this clean energy source in developed nations, underlining a departure from antiquated energy paradigms.

Additionally, LawnGenie operates with zero greenhouse gas emissions, contributing substantially to the global endeavor to combat climate change. This conscientious approach not only resonates with responsible living but also underscores the potency of collective action in shaping a more sustainable future, irrespective of the scale.

Fundamentally, LawnGenie's overarching ambition is to furnish an intelligent alternative to conventional mowers. As we stand at the precipice of the automation age, LawnGenie emerges as a beacon, signifying our inaugural strides into the realm of comprehensive automation. Through this transition, we bridge the past with an epoch that enshrines ingenuity, sustainability, and an elevated quality of life.

1.3 Research Gaps

The literature review section highlights an array of research endeavors that have delved into the development of autonomous grass-cutting systems. However, certain gaps have been identified in the existing body of research, which we aim to address comprehensively in this section.

One study introduces Robomow's Friendly Home lawnmowers as an intelligent robot mower that offers unparalleled efficiency and user-friendliness. Despite its merits, the installation process presents a significant challenge, demanding the placement of a perimeter wire to define mowing boundaries. This wire creates a virtual wall that's only visible to the mower, but the setup remains cumbersome [3][4].

Similarly, other commercially available autonomous mowers, like the Zucchetti Lawnbott, rely on the perimeter wire concept for navigation. These mowers halt, pivot, and adjust course upon collision with obstacles, a limitation that could be mitigated through the development of obstacle-detection systems [5].

The Husqvarna Rider R155 AWD is cited as another example of an effective mower, yet it shares the installation complexities associated with the Robomow and Lawnbott models. Moreover, engine vibrations pose a potential annoyance during prolonged mowing sessions [7].

Conversely, some researchers propose that push mowers or hand lawn mowers are more ecologically advantageous compared to electric counterparts [6]. However, the manual labor and time investment required for these methods render them impractical.

In contrast, a solar-powered lawnmower showcased in a journal article demonstrates efficiency through the use of renewable solar energy. Regrettably, this design lacks an obstacle sensor, which is crucial for identifying impediments while the machine advances. This oversight could lead to the deterioration of the solar panels. These research gaps underscore the pressing need for refinement and enhancement in our own study, with the goal of developing a superior, more efficient system [8].

In summary, the literature review illustrates the existing landscape of grass-cutting systems, highlighting both their accomplishments and limitations. The identified gaps in research underscore the impetus for our own investigation to bridge these shortcomings and contribute to the advancement of a more efficient and effective autonomous grass-cutting solution.

1.4 Problem Definition and Scope

The labour costs associated with a rudimentary task like mowing the lawn are enormous. Moreover, many other costs are associated with this task apart from the physical. The environment and ecosystem are also impacted by the same.

In earlier times, most of the tasks were carried out manually. However, with technology developing at a rapid pace, the need for human labour is decreasing day by day. Autonomous systems are being employed in every field and domain in this current day and age, and it is imperative that we come up with a novel solution to reduce the manual labour involved in a task like mowing.

This is precisely what we are trying to achieve as well.

The main objective of this project is to create a fully automated robotic grass-cutting system capable of performing the task at hand with minimal human intervention. The robotic system will not only make use of advanced Deep Learning and Computer Vision techniques for its operation but will also harness solar energy for its working.

1.5 Assumptions and Constraints

TABLE 1: Table of Assumptions and Constraints

S. No.	Assumptions and Constraints
1	The device will be used in appropriate environments where it can actually be operated and will have enough grass which can be mowed or chopped down by making use of LawnGenie.
2	It is assumed that the application for operating LawnGenie will always be used on mobile phones with good performance. If the phone does not have enough hardware resources available for the application, it may not work as intended or even at all.
3	Since the application needs to communicate wirelessly with LawnGenie itself, there is a need for strong internet connectivity. It will be assumed that the users will possess decent internet connectivity.
4	All the required resources for the proper working of this automated device, like equipment, tools, or materials, will be in good condition to be used throughout the time that LawnGenie is in use.

1.6 Standards

- To ensure unwavering quality throughout the project, meticulous control and tracking of all associated documents will be paramount. This vigilance extends to the efficient management of all generated materials.
- Efficiency will be upheld by the adoption of version control systems like GitHub. This approach guarantees the synchronization and real-time updates of all project components, thus safeguarding their up-to-date status.
- The project's constituents will adhere to a uniform naming convention, formatting, and style, meticulously maintained across every phase of the project's life cycle. This

steadfast consistency not only streamlines collaboration but also enhances the clarity and coherence of the project's output.

- While striving for top-tier standards and procedures, the project will be careful not to impose redundant regulations or excessively intricate processes. The focus remains on demonstrating the evident quality of the established standards and procedures, all the while ensuring they facilitate productivity rather than hinder it.

1.7 Objectives

The approved objectives of our project are as follows:

- Develop a fully automated robotic system capable of effectively maintaining lawns with minimal human intervention.
- Implement dual operational modes – manual and automatic – to cater to user preferences and different scenarios.
- Integrate advanced navigation and path planning algorithms to ensure precise and efficient movement across the lawn.
- Integrate a water irrigation and seed dispenser system.
- Implement a user-friendly interface for mode selection, scheduling, and monitoring, ensuring ease of interaction for users.

1.8 Methodology Used

The methodology to achieve the objectives that has been set have been mentioned below:

- **Understanding and Developing a Localization and Mapping System:**
  Localization and Mapping can be implemented in two ways.
  The first method is making use of images acquired from cameras and other image sensors to determine the amount of movement needed and simultaneously create a map of the obstacles in its surroundings and avoid moving over the same area twice.

  The second method uses Light Detection and Ranging (LiDAR) technique. This method primarily uses a laser sensor which is more precise. The output values from laser sensors are generally 2D (x, y) or 3D (x, y, z) point cloud data. The laser sensor point cloud provides high-precision distance measurements and works very effectively for map construction with SLAM.

- **Developing a Power Supply System:**
  LawnGenie will make use of solar power for its functioning.
  Solar panels will be mounted in a particular arrangement at an angle of 45 degrees. In doing so, the solar panel can easily receive solar radiation with high intensity from the sun. We will also use LDR sensors and a DC motor to help rotate the panel to get as much sunlight as possible from the sun. The solar panels will convert solar energy into electrical energy, which will be stored in batteries using a solar charger.

- Testing of Software and Hardware Systems
- Hardware and Software Interfacing
- Optimizing Final Design

1.9 Project Outcomes and Deliverables

- Our project aims at developing a prototype of an automated system, which will help reduce manpower and physical effort. Certain regions like large lawns in schools, colleges, and parks are maintained manually. The gardener uses hand scissors to cut and maintain the property regularly, which takes up a lot of time. So, we are proposing a fully automated working robot LawnGenie, powered by solar energy.

- Our proposed system will take live video input using a webcam. As we are focused on creating a real-time application and design, we will allow LawnGenie to capture all the images, just like a human being. This feature will be implemented by using OpenCV and Computer Vision techniques.

- LawnGenie will detect and map the grass region and localize it in that particular area simultaneously. We will use a mapping algorithm for this purpose. An example of such an algorithm used in today's time is SLAM (Simultaneous Localization and Mapping). SLAM simplifies data collection and can be used in outdoor or indoor environments.

- As mentioned above, we will need to ensure that we have an obstacle-free path so that LawnGenie can operate without any hindrances. We are using the You Only Look Once (YOLO) algorithm for this purpose. For robots, the algorithm should be able to detect objects and make inferences within microseconds. YOLO performs all of its predictions with the help of a single fully connected layer.

- LawnGenie is partially powered by solar energy. The solar trackers are used to continuously direct the solar panel toward the sun’s rays, thus maximizing the exposure of this system. The system will efficiently track the sun's position in the sky and generate more electricity because of increased direct exposure to the sun's rays.

1.10 Novelty of Work

Electric grass-cutting machines have seen numerous innovations, and solar-powered counterparts have emerged recently. Despite achieving the basic goal of lawn mowing, existing devices often exhibit inefficiencies. Market options possess merits like versatility for various landscapes and non-smooth surfaces, yet are marred by high costs and design drawbacks.

These mowers utilize diverse cutting patterns – from random to cross-like – but this approach often necessitates multiple passes over the same area. This redundancy saps energy and extends mowing time. Moreover, these machines persist with outdated technology despite the rapid evolution in recent years.

LawnGenie counters these limitations with a mission to craft a fully automated grass-cutting robot that embraces cutting-edge technology and solar power, achieving ecological consciousness and efficiency at a fraction of market costs. This robot further distinguishes itself through dedicated modules for water and seed dispensing, catering to a wide range of needs.

2.1 Literature Survey

In software and system engineering, requirement analysis encircles the tasks those go in finding the requirements or conditions to satisfy for a replacement or altered product or project, taking account of the presumably conflicting necessities of the assorted stakeholders, analysing, documenting, verifying and managing software or system necessities

2.1.1 Related Work

Research was done at the outset of this project on four various pre-existing robotic lawn mowers produced by three distinct well-known lawn care firms.

Each automatic lawn mower now in use operates according to a different basis. For example, the Robomow from Friendly Robotics (2011) needs the operator to specify the garden border once during setup. The garden's boundary and any area that the robot is not supposed to cover are marked off with a battery-operated wire. The robot is confined inside the allocated area using Robomow's special sensors, which can identify the cables [3].

As shown in the image below Figure 3, the robot moves around the lawn in a methodical criss-cross manner.

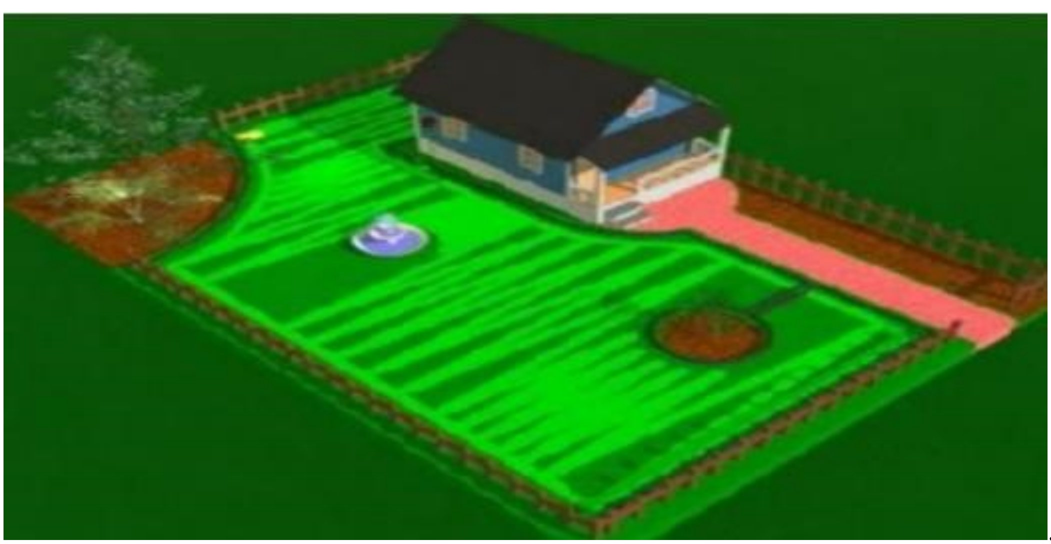


FIGURE 3: Criss-Cross Cutting Pattern of Robomow

Similar to other technologies, the Robomow operates on the premise that its cutting area must be constrained by a perimeter wire. The Husqvarna and LawnBott both operate according to a random operating concept, which means that they do not adhere to any particular cutting pattern, as shown in Figure 4. Additional characteristics and the cutting pattern may also be different between them.

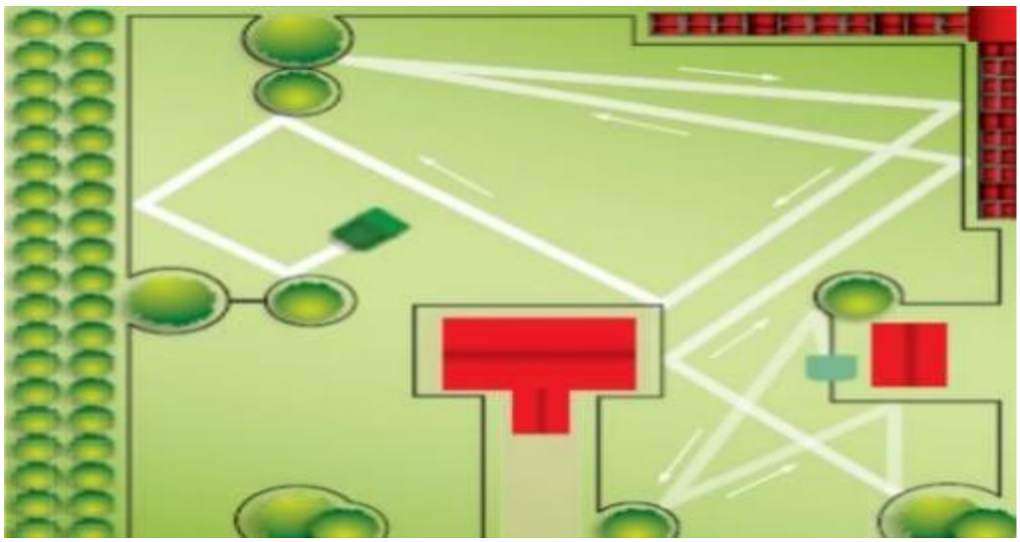


FIGURE 4: Random Cutting Pattern of LawnBott

The design of the system includes the following drawbacks: A wiring flaw might send the gadget the wrong data, which would prevent it from functioning as it should. Cutting pattern inefficiency: Because the robot must pass over the same area more than once, the crisscross pattern used by Robomow and the random one used by LawnBott and Husqvarna are all not particularly efficient [7] [18]. As a result, more energy is lost and the overall completion time increases. While each of these three robotic lawn mowers has its own special characteristics, they all work similarly.

The number of wheels on the mower, including driving wheels and guiding wheels, was the first characteristic of these mowers that was investigated.

Two plastic driving wheels are utilised by all three robots. The Honda Miimo and the Husqvarna, on the other hand, both featured two front guide wheels, whilst the Landroid only had one [10] [11]. It was discovered that all of the guide wheels on these mowers are little and made of plastic. The scientists reasoned that a rover may have trouble navigating a sizable area of land with thick, uneven, and probably damp grass, such as that of a sizable solar farm, if its wheels were made of this material, had this tread, and were this size.

While the Landroid's cutting disc is offset from the centre and tangent to the side of the mower in order to accurately cut at an area's edge, the cutting discs of the Honda Miimo and Husqvarna are centred beneath the rovers [11]. String-based trimmers must be utilised as blades, which cut very effectively but cannot be used for the competition, are not an option. The batteries and battery longevity are the final subject of comparison. Different voltages of lithium-ion batteries were used by the three mowers. The Worx Landroid can cut up to a quarter of an acre and charges in 90 minutes with a 20V battery [10].

The Husqvarna is more effective than the Honda Miimo when compared with their respective run time to charge time ratios, which are 2.9 and 1, respectively [11]. For every minute it is charged, the Husqvarna will operate for 2.9 minutes.

Even though the Husqvarna is unquestionably the most effective, all three of these mowers, provided they can successfully navigate the solar farm, would be able to trim the competition area of 10 feet by 50 feet in 15 minutes.
These are the technologies that are now available on the market, however each product has a high price.

2.1.2 Research Gaps of Existing literature

- **Traditional hand-held lawn mowers**
  In many parts of the world, many farmers continue to use traditional hand-held lawn mowers, which are convenient to use and operate in the lawn mowing area but have many drawbacks, like heavy engines and heavy body burden; This device consists of linear blades and it is not affected by climatic conditions.

- **Gasoline Grass mowers**

  To assist lower air pollution, low emission gasoline engines with catalytic converters are being produced. To lessen the noise pollution, improved muffling devices are also being fitted. Mowers with batteries are also becoming more feasible. These new mowers will silently cut lawns for around an hour each charge, without the typical cloud of blue smoke hanging in the air, while being significantly smaller with an average cutting swath of only 17–19" [12].

- **Electric Operated Driving lawn mowers**

  Bulski identifies the sound created by the machine that is making noise pollution. He researches sound created by the machine and gives the result of how to remove the sound while cutting the grass of the lawn or ground. As looking to the petrol engine, it makes air pollution to environment so from my recommendation it should be implement on electric operated lawn mower. As looking to the petrol engine, it makes air pollution to environment so to resolve this problem people start using electric operated lawn mower. Compared to the traditional mower, it is much easier to use and less noisy.

- **Self- Efficient and Sustainable Solar Powered Robotic Lawn Mower**

  Introducing a groundbreaking advancement in lawn care technology, the project heralds a solar-powered lawn mower that ingeniously employs solar energy to power its cutting-edge LED headlights. Unlike conventional lawn mowers, this innovation elevates the efficiency and user experience to unprecedented heights.

  The core feature of this visionary solution is its utilization of solar energy harnessed through an advanced 12V 310m solar panel, consisting of 24 individual sun cells generating 0.5 volts each. This ingenious integration not only showcases sustainability but also eliminates concerns of overload, rendering it a marvel of efficient design.

  The significance of this project is further magnified by the integration of state-of-the-art IR sensors enhanced by 555 ICs, each strategically placed within a meter's range. These sensors provide unparalleled obstacle detection, elevating the safety and autonomy of the lawn mower. The dual-sensor configuration ensures swift response to impediments, directing the mower away from obstacles and promoting seamless operation. Recognizing the potential for enhanced real-time performance, future iterations may harness high-end DSP processors to further expedite obstacle identification and reaction.

This pioneering approach finds its roots in the conceptual framework presented by Wassell, where an electric motor, rechargeable battery, and the innovative addition of a photovoltaic cell panel mounted on the lawn mower's handle redefine the possibilities of eco-friendly lawn maintenance. In summation, the solar-powered lawn mower with detection headlights stands as a testament to innovation, sustainability, and enhanced user experience. As we navigate the demands of modernity, this project illuminates a path towards greener, smarter, and more efficient lawn care practices.

From the standpoint of efficacy, a solar-powered lawnmower was compared and examined with the gasoline-powered lawnmowers. The solar-powered mowers were found to be more effective, silent, and cost-effective to operate when the two mowers were compared [8]. Because it was solar powered, no air pollution was created, in contrast to gasoline mowers that made a lot of noise and had an adverse effect on the environment.

In the Willsie research [8], a lawnmower blade was created with an enhanced blade bar that was flat with a tiny twist. On both ends of the blade, pivotal cutting discs were installed. The blades had blower components attached to each end, which blasted the grass. Maximum grass cuttings could be thrown from the mower's housing while the blades were rotating thanks to the design.

The approach employed in carrying out this project differs from the numerous methodologies used in the afore mentioned research work, considering the prior work performed by others in accordance with this project.

Our suggested lawn mower utilises a variety of machine learning algorithms and is entirely powered by solar energy, making it more practical and superior to use in the modern era. It is intended to increase field cutting efficiency when compared to the conventional lawn mower powered by fossil fuels.

2.1.3 Detailed Problem Analysis

The detailed analysis of literature and the problem at hand done by the group has been tabulated below in Table 2.

TABLE 2: Table depicting the findings of team members considered for the literature survey

S. No.	Roll Number	Name	Paper Title	Tools/ Technology	Findings	Citation
1	102016081	Abhay Bedi	Implementation of Automatic Solar Grass Cutter in International Journal of Advanced Research in Electrical (IJARE).	The design contains a microcontroller, multiple sensors and a solar charging system.	Knowing that the user would be randomly holding the robot. They used Nickel-metal hydride (NiMH) because it gives a low charging current, it will not overcharge.	[14]

2	102016096	Abhav Goel	Self-Efficient and Sustainable Solar Powered Robotic Lawn Mower in International Journal of Trend in Research and Development (IJTRD).	Array of sensors for safety purpose, IR sensors are used to detect the obstacles, along with that solar panels are also used.	Sometimes response of the system is too slow so in real-time high-end DSP processors is recommended that can process much faster. Unlike other robotic lawn mowers in the market, this design requires no perimeter wires to maintain the robot within the lawn	[15]
3	102016091	Aparna Sood	Automated Solar Grass Cutter in International Journal of Scientific Development and Research (IJSDR)	The system uses 12v batteries to power the vehicle movement motors as well as the grass cutter motor. They also use a solar panel to charge the battery so that there is no need of charging it externally.	The microcontroller moves the vehicle motors in the forward direction in case no obstacle is detected. If in case an obstacle is detected by the sensor, then the microcontroller stops the grass cutter motor to avoid any damage to the object coming in its path.	[16]

4	102017118	Suvansh Sharma	Solar Based Grass Cutting in International Journal of Electrical and Electronics Engineers (IJEEE)	Many components are used like DC Motors for rotating wheels and blade, battery, Solar panel, IR sensor, Collapsible blade, transmitter and Receiver.	They design and build a remote-controlled grass cutter. Here Transmitter continuously transmits the rays if any obstacle comes in front of it. After rays reflected towards the receiver, it sends data to decoder and then pass to microcontroller.	[17]

5.	102016097	Pratham Mittal	Solar powered wireless multifunctional robots	Photovoltic cells to convert sunlight into electricity.	The proposed system expands operational range through the use of solar power and wireless cameras for cost-efficient live streaming. This versatile robotic platform can be used not only for surveillance and rescue operations, but also for tasks such as grass cutting. The system alerts the user of any potential intruders and can effectively handle various outdoor maintenance tasks.	[14]

2.1.4 Survey of Tools and Technologies Used

Hardware tools used by this system and their requirements are as follows:

TABLE 3: Hardware tools used

S. No.	Name of Hardware	Usage
1	Solar Panel	Used for providing power source to LawnGenie
2	Arduino Uno Board	Controls the functioning of all hardware components of system
3	Battery	Used for storage of power and functioning of all systems
4	Motors	Controls the movement of wheels and blade
5	Blades	Used for cutting the grass
6	Motor Drivers	Controls the functioning of the motors
7	PCB Board and ESC	Used to connect and place all components
8	Wires and Cables	Used for connecting all the components
9	Switch	To on/off the blade
10	Sensors	Used for obstacle detection and avoidance
11	Wheels	Utilised for movement of LawnGenie
12	ESC	Controls the BLDC motor used in the blade

Software tools used by this system are:

TABLE 4: Software and Technology tools used

S. No.	Name of Software	Usage
1	Arduino IDE	Used to code the control and working of hardware
2	Wireless Module	Interconnectivity between all the systems.

2.1.5 Summary

Approximately 54 million Americans mow their lawns every weekend, burning 800 million gallons of petrol and generating tonnes of air pollutants in the process. The machinery and tools used for this activity release large quantities of carbon monoxide, volatile organic compounds, and nitrogen oxides. As a result, they contribute up to 5% of the air pollution in the United States of America [9]. The same has an influence on the ecology and the environment. On the opposite end of the scale, the recent decline in rural labour and the ageing of that workforce have had a detrimental effect on agricultural productivity, forcing us to rely more and more on technology to increase production efficiency.

There are many other problems related to the models and robots already available in the market. They are as follows:

- The labour costs associated with a rudimentary task like mowing the lawn are enormous.
- Traditional Lawn mowers emit high levels of carbon monoxide, volatile organic compounds, and nitrogen oxides, cause to air pollution and global warming.
- In traditional grass cutters, human intervention is highly involved.
- Due to usage of heavy engines and heady bodies, noise pollution escalates more.

Our proposed system can perform the task at hand with minimal human intercession involved.

2.2 Software Requirement Specification

2.2.1 Introduction.

2.2.1.1 Purpose

LawnGenie's mission is to assist people in maintaining their lawns while conserving a precious resource: our time. Our automated grass-cutting robot, LawnGenie, is a system that

combines effective hardware modelling approaches with extremely precise artificial intelligence and machine learning ideas to produce a state-of-the-art piece of machinery.
It is an attempt to produce a cost effective and feature-rich system that is not only affordable but also easy to use. With LawnGenie, we aim to create a device that adds on more features to what is already available and still be able to drive down the costs to as low as possible.

2.2.1.2 Intended Audience and Reading Suggestions

The LawnGenie targets each and every person, as this device will aid the building of an ecofriendly system. Everyone seeking a better way to mow their lawns, playgrounds, fields, etc., is the target audience for this article. The current technology commonly used for cutting grass is the manually handled device. We are trying to make a daily purpose robot that is able to cut the grasses on the lawns.

2.2.1.3 Project Scope

LawnGenie- the automated solar grass cutter is a fully automated grass cutting robotic vehicle powered by solar energy that also avoids obstacles and is capable of fully automated grass cutting without the need for any human interaction.

The scope of the project is as follows:

- Investigate the value and benefits of developing a robot using Artificial Intelligence and various other technologies for people that can help reduce the cost and the manual work
- Study the feasibility and different options to enhance the model for detecting objects
- Study the YOLO architecture procedure for detecting objects and increase the accuracy of findings
- Design and develop a prototype system that includes the hardware of LawnGenie with a solar panel
- Evaluate and review the positives and weaknesses of the project build outcome, seek and identify for further improvement

2.2.2 Overall Description

2.2.2.1 Product Perspective

We aim to develop a system that works without the need for human surveillance every time and is made irrespective of the physical presence of a human supervisor.

We want to create a system that automatically cuts the grass on the ground. The software and hardware agents will be compatible and help one operate LawnGenie with just one tap of a button on the mobile phone.

2.2.2.1 Product Features

- Performance: LawnGenie is reliable and can be used in any landscape or weather conditions
- Scalability: Our system is highly scalable, and new features can be added to it in order to improve its performance
- Availability: LawnGenie does not require manual support; hence is available for users at any time. It is also accessible by anyone as its cost is less than other lawn mowers.
- Localization: LawnGenie can be used in various locations and terrains just by slightly modifying the internal coding

2.2.3 External Interface Requirements

2.2.3.1 User Interfaces

We would require an interactive app/web interface which would be easily accessible by the owner of the robot for controlling LawnGenie.

- The GUI should be user friendly
- The GUI should be highly responsive
- User’s data should be secured

2.2.3.2 Hardware Interfaces

The hardware interfaces that are required for the project are as follows:

- Arduino Uno Board
- Bluetooth
- Laptop
- Connecting wires, cables, and cutters
- Motor Drivers
- Sensors

2.2.3.3 Software Interfaces

Software interfaces include the use of the following:

- Python Programming Language
- Arduino IDE

2.2.4 Other Non-Functional Requirements

2.2.4.1 Performance Requirements

The model should be efficient, responsive, and accurate, reducing the user's time and effort. This way, the user would more likely use LawnGenie and save time and money.

2.2.4.2 Safety Requirements

- Proper wiring and safety should be ensured to maintain industry standard
- Quality wires and material
- Do not hamper with the wiring or components of robot

2.2.4.3 Security Requirements

The system should be reliable and safe from external threats, bugs and hacks as some important information about the user might be hacked or leaked through online source. So, our model should be safe from external threats like information hacking.

The system should be end-to-end secure for the user so that personal information is visible to user or owners and not to any third-party source or person.

2 .3 Cost Analysis

TABLE 5: Table of Cost Analysis

S.No.	DESCRIPTIONS	PRICE (₹)
1	Arduino Uno R3 Development Board	645
2	Ultrasonic Sensor X 2	190
3	150RPM DC Motor X 4	716
4	PCB Board	101
5	1000RKV Brushless Motor	335
6	Servo Motor	184
7	L298N Motor Driver	239
8	Toggle Switch	70
9	Cable for Arduino	40
10	Mounting Clamp	112
11	Wheels	224
12	Lipo Battery	300
13	DC-DC Converter	450
14	Male-Female Connector Pair for Lipo	68
15	Lithium Polymer Battery Pack	1699
16	Water suction pump	400

17	20A Bidirectional Digital ESC	759
18	Solar Panel and circuit	300
19	Relay	200
TOTAL		7032

2 .4 Risk Analysis

Risks to Consider:

- Inaccurate values by the sensors.
- Data lost or corrupted while processing.
- Too much delay in response.
- Hardware components stop working
- Physical harm caused by blade of LawnGenie

Impact of Risks:

TABLE 6: Table of Impact of Risks

S.No.	Risk	Probability	Impact
1	Inaccurate values by the sensors.	Medium	Medium
2	Data lost or corrupted while processing	Medium	High
3	Too much delay in response	Low	Medium
4	Hardware components stop working	Low	High
5	Physical harm caused by blade of LawnGenie	Low	High

METHODOLOGY ADOPTED

3.1 Investigative Techniques

Investigative Technique Involved: DESCRIPTIVE

In our research, descriptive investigative methods are used with the goal of applying our engineering expertise to benefit society. The main goal of this project, LawnGenie, is to create a new automated design for the generic lawn mower using the latest and up-to-date technologies; hence this is the investigative technique that we have adopted.

The people who use lawnmowers operate existing systems manually, which is a very time consuming task, and they also usually operate on fuel, which can cause pollution. Automating the generic lawn mower will prove to be very helpful and environmentally friendly.

Our project's unique architecture and design eliminate physical interaction between machines and humans, and help it stand out from all of solutions and systems that are currently present in the market.

Investigative Technique Involved: EXPERIMENTAL

In our project, apart from Descriptive Investigative Technique, we have also used the Experimental Investigative Technique as at each and every step of our project our proposed methods and hypothesis are being analysed, and the hypothesis is being tested in order to calculate its effectiveness and make sure that we are building a system that is better than the rest.

The position on the map must also be determined by the automated lawn mower. Simultaneous Localization and Mapping is the ability of an autonomous robot to find itself in the environment and create a map at the same time. As we set up the system, the path planning algorithm makes an accurate estimate of the present position by observing the surrounding area using sensor data and computer vision technologies. When we repeat these actions, the path planning system will keep track of our movement through the asset.

Design and Implementation of Application

The operator can use a mobile application to start and stop the machine. All the modules can be created using various software engineering practices and then implemented accordingly.

Design and Implementation of Hardware

The key hardware components of the Fully Automated Solar Grass Cutter model encompass solar panels, batteries, microcontrollers, sensors, motor drivers, DC motors, blades, as well as mechanisms for water and seed dispensing. The solar panels capture abundant solar energy, constituting the primary energy source. This energy is stored within batteries for later use. The microcontroller plays a pivotal role in the system, hosting program codes that manage the solar tracking system's orientation and the path planning algorithm. It communicates with the motor drivers, instructing the DC motors to adjust the direction and avert obstacles.

Moreover, the model integrates additional functionalities. The water dispenser mechanism employs a relay switch to facilitate controlled water distribution. Simultaneously, the seed dispensing feature enhances lawn rejuvenation, operating in coordination with the microcontroller's programmed instructions. The integration of these components transforms lawn maintenance into an automated, sustainable, and multi-functional endeavor.

3.2 Proposed Solution

Decades of research have fueled the development of various automation technologies, yielding remarkable innovations such as our creation: LawnGenie. This model represents a stride in automating everyday devices, exemplifying the evolution of convenience. LawnGenie's primary goal is to transcend the ordinary lawnmower, embracing automation's potential. Beyond grass cutting, it integrates advanced features like a seed dispenser and a water dispenser, facilitated by a suction pump mechanism.

Initialization commences with the Localization and Mapping module, utilizing ultrasonic SLAM technology. The rotating ultrasonic sensor navigates a 180-degree path, defining the robot's course. Operating in dual modes—manual and automatic—LawnGenie adapts to user preferences.

With sustainability in focus, LawnGenie harnesses solar power through precisely angled solar panels at 45 degrees. This optimal orientation captures abundant solar radiation, subsequently converted into electrical energy. Battery storage, facilitated by a solar charger, ensures continuous operation even during overcast conditions when solar charging is limited.

Should sunlight be insufficient for direct charging, stored energy powers the grass cutter. LawnGenie embodies automation's multifaceted potential, redefining routine lawn maintenance.

3.3 Work Breakdown Structure

TABLE 7: Table of Work Breakdown Structure

S.No.		Name	Start Date	End Date	Progress
1	**Initializing the Project**				
1.1	Project Management Phase	All	10-01-23	19-01-23	100%
1.1.1	Feasibility Study	All	12-01-23	14-01-23	100%

1.2	Requirement Gathering Analysis	All	20-01-23	21-01-23	100%
1.2.1	Analyse Requirements	All	22-01-23	23-01-23	100%
1.3	Research Work	All	2-02-23	09-02-23	100%
2	**Design Phase**				
2.1	Basis of project	All	15-02-23	16-02-23	100%
2.1.1	Brain storming Session	All	15-02-23	15-02-23	100%
2.1.2	Role division	Suvansh	26-02-23	28-02-23	100%
2.2	Specifications	All	28-02-23	15-03-23	100%
3	**Implementation**				
3.1	App development	Abhay			20%
3.4	Mapping Implementation	Pratham	01-06-23	10-07-23	50%
3.6	Integrating hardware with software	Abhav	12-07-23	15-07-23	60%
3.7	Investigation of modules	Aparna	15-07-23	16-07-23	90%
3.8	Review of errors	Pratham	18-07-23	20-07-23	100%

3.4 Tools and Technology

- **Microcontroller/Arduino Uno Board**

  The ATmega328 is a microcontroller board based on the Arduino Uno. It will be used to manage all of the hardware devices using a mobile device.

- **Software used by this system are:**

TABLE 8: Table of Software Required

S. No.	Name of Software

1	Programming Languages: Python
2	Arduino IDE
3	Wireless Module

- **Hardware tools used by this system are:**

TABLE 9: Table of Hardware Required

S. No.	Name of Hardware
1	Solar Panel
2	Arduino Uno Board
3	Battery
4	Motors
5	Blades
6	Motor Drivers
7	Transistor
8	PCB Board and ESC
9	Wires and Cables
10	Switch
11	Sensors
12	Wheels

3.5 Technical Innovations

3.5.1 Simultaneous Localization and Mapping (SLAM)

Our project leverages Simultaneous Localization and Mapping (SLAM) techniques to achieve accurate mapping of the lawn environment while determining LawnGenie's position. Through SLAM, LawnGenie effectively navigates unknown terrains by creating a map and localizing itself simultaneously.

3.5.2 Drip irrigation

Drip irrigation, seamlessly integrated into our innovative robot, revolutionizes precision lawn care. This cutting-edge system delivers water directly to plant roots, conserving resources while enhancing plant health. The robot's autonomous navigation combined with the drip irrigation mechanism ensures optimal water distribution across the entire lawn, reducing water wastage and promoting lush, vibrant vegetation. This synergy of advanced robotics and drip irrigation technology showcases our commitment to sustainable landscaping practices, providing efficient and eco-friendly lawn maintenance for modern outdoor spaces.

3.5.3 Seed dispenser module

Our robot features a state-of-the-art seed dispenser module that redefines planting efficiency. This module, seamlessly integrated into the robot's design, accurately dispenses seeds with precision and consistency. By eliminating manual labor and guesswork, the robot ensures uniform seed distribution, enhancing germination rates and overall crop yield. This innovative technology empowers modern agriculture by automating the planting process, saving time, and optimizing resources. With the seed dispenser module, our robot offers a futuristic solution that streamlines farming practices and contributes to sustainable food production.

4.1 System Architecture

The following block diagram depicts a high-level view of the product under development and showcases how its different components interact with each other. It describes the static structure of the system. The main components are the Localization and Mapping Module, Obstacle Detection and Avoidance Module, the Solar Power Module, the Mobile application for wireless communication with LawnGenie, and of course the hardware components.

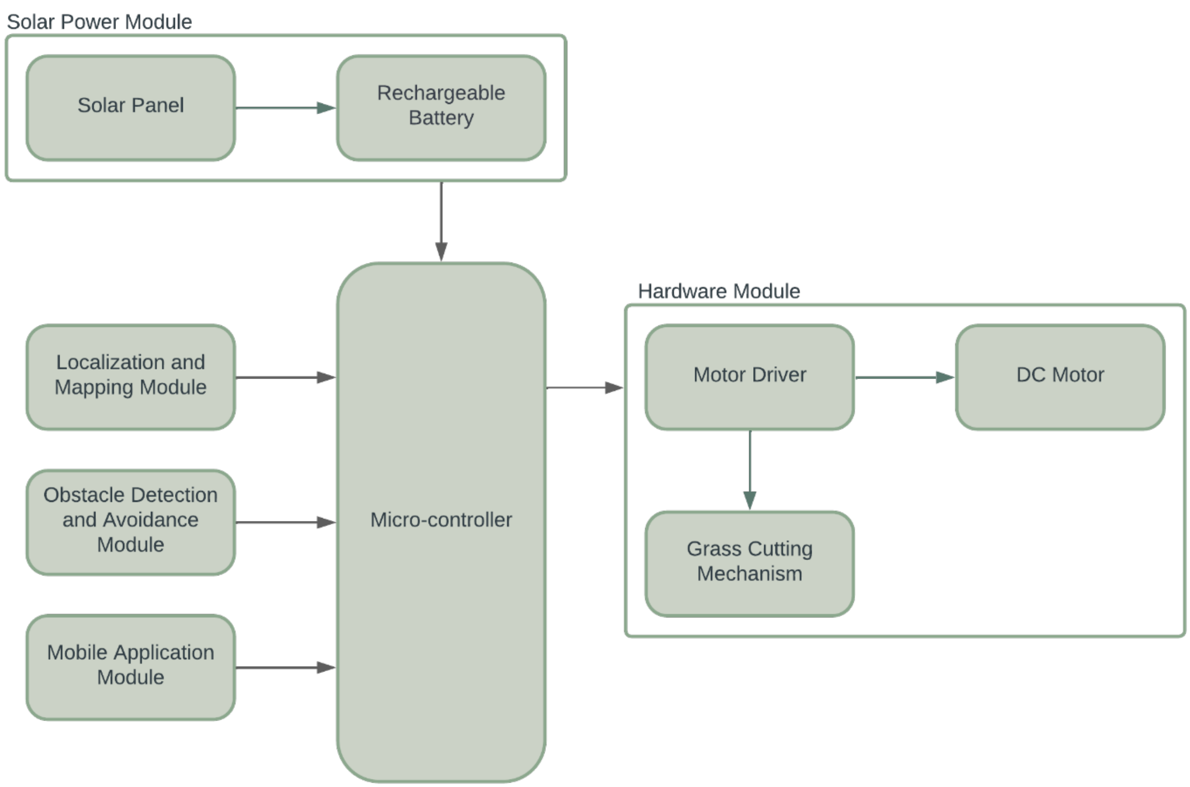


FIGURE 5: Block Diagram depicting the modules of LawnGenie

The architecture of LawnGenie's system has been further illustrated in the following Schematic Diagram. The diagram shows the proposed plan for the setup of the various hardware components on the automated solar grass cutter and where they will be placed.

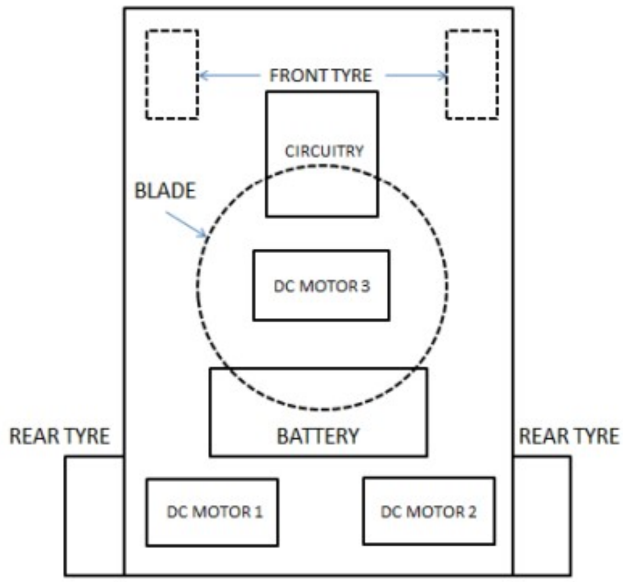


FIGURE 6: Schematic Diagram of LawnGenie

The next design-level diagram is the State Chart Diagram. It describes the different states of a component LawnGenie. The states are specific to each component of the system. The different states of the objects are controlled by external or internal events, caused by the other modules of LawnGenie.

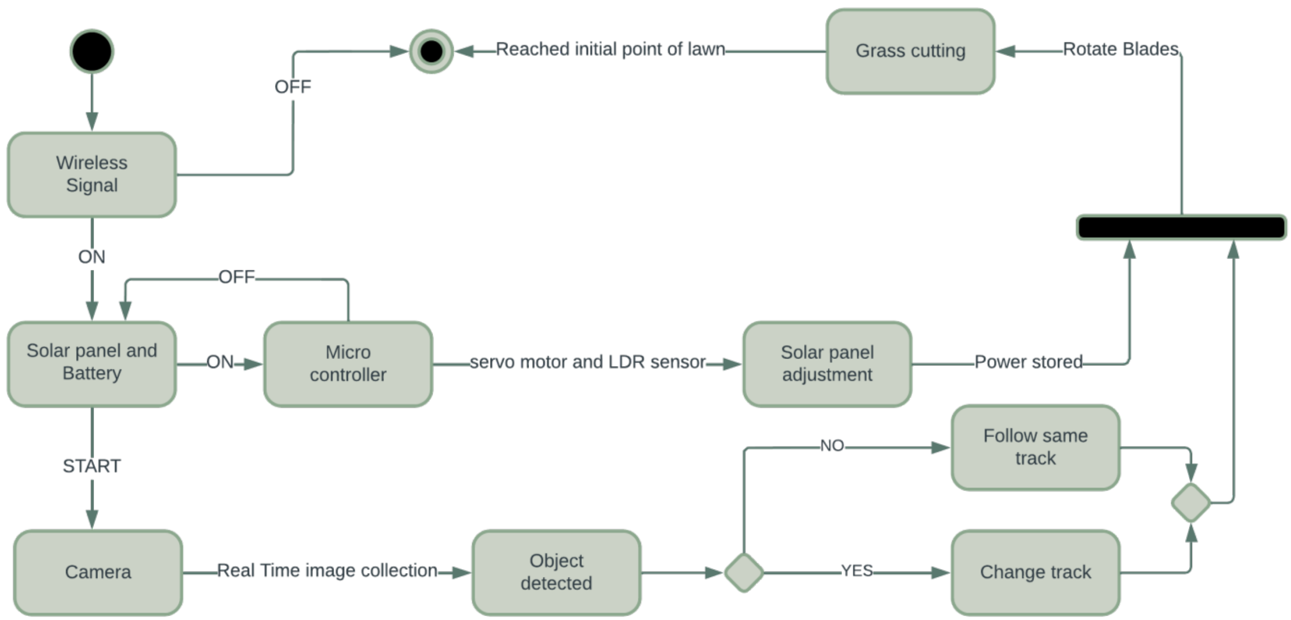


FIGURE 7: State Chart Diagram

4.2 Design Level Diagrams

In the following section, we have included design-level diagrams in order to explain our proposed solution of LawnGenie better and to diagrammatically showcase the various components of the system and how they interact with each other.

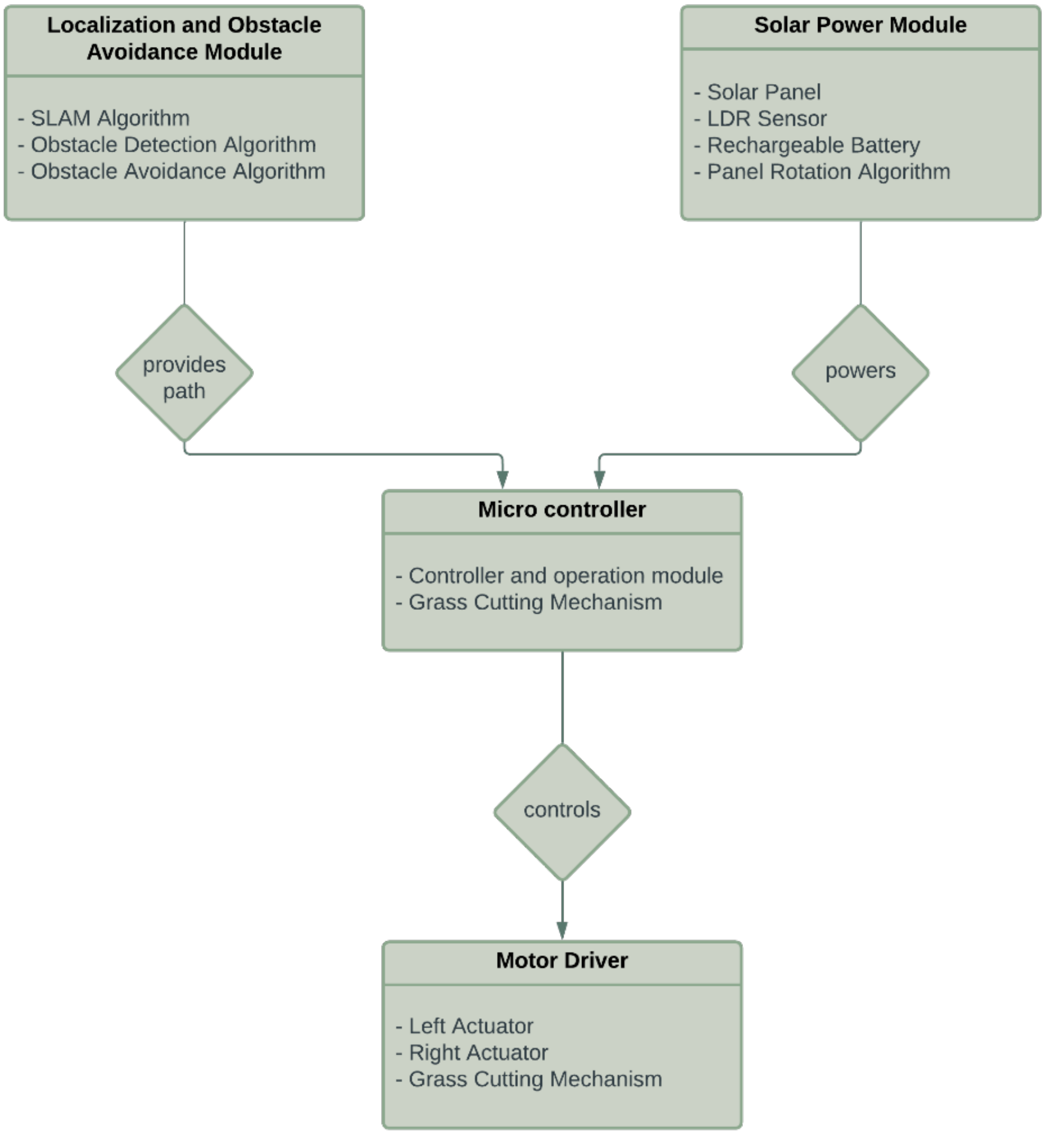


FIGURE 8: Relationship Diagram

The next design-level diagram is the Sequence Diagram.

It depicts the interaction between the modules and objects in a sequential order i.e., the order in which these interactions take place. It describes how and in what order the objects in a system.

It specifically focuses on the lifelines of the processes that live simultaneously, and the messages exchanged between them to perform a function before the lifeline ends. The interactions between modules of LawnGenie over time are represented as messages drawn as arrows from the source lifeline to the target lifeline.

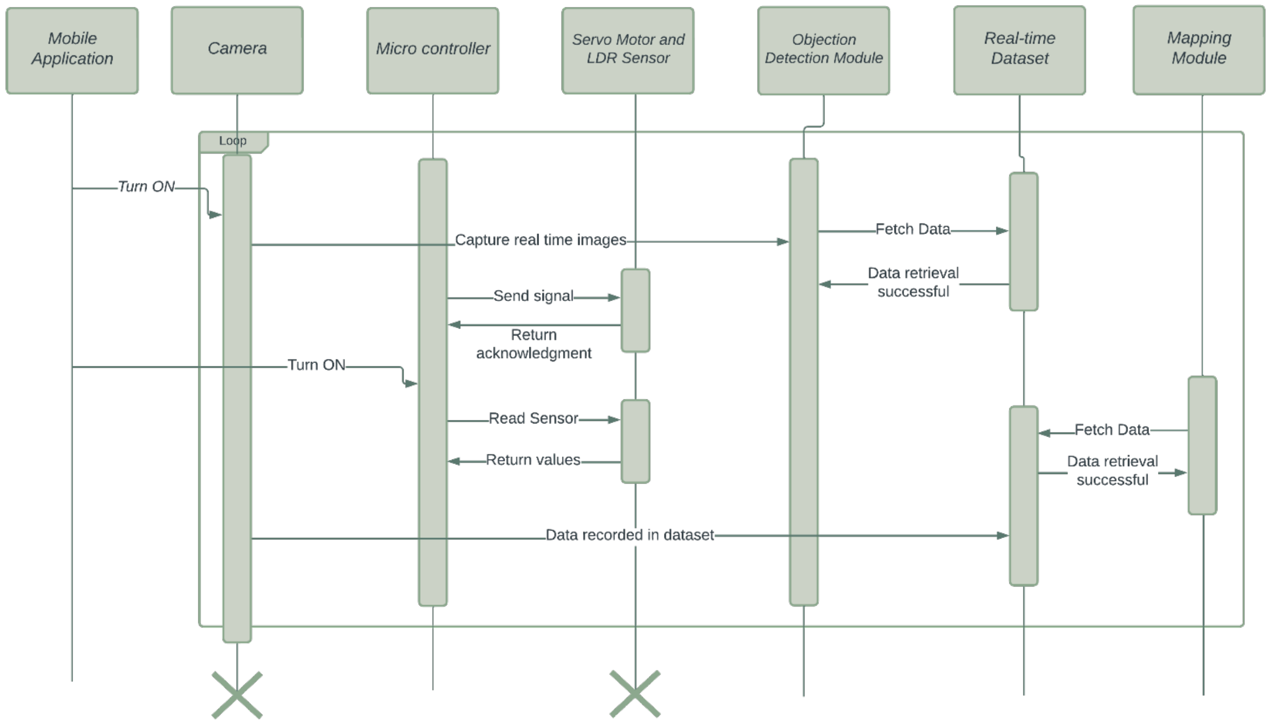


FIGURE 9: Sequence Diagram

4.3 User Interface Diagrams

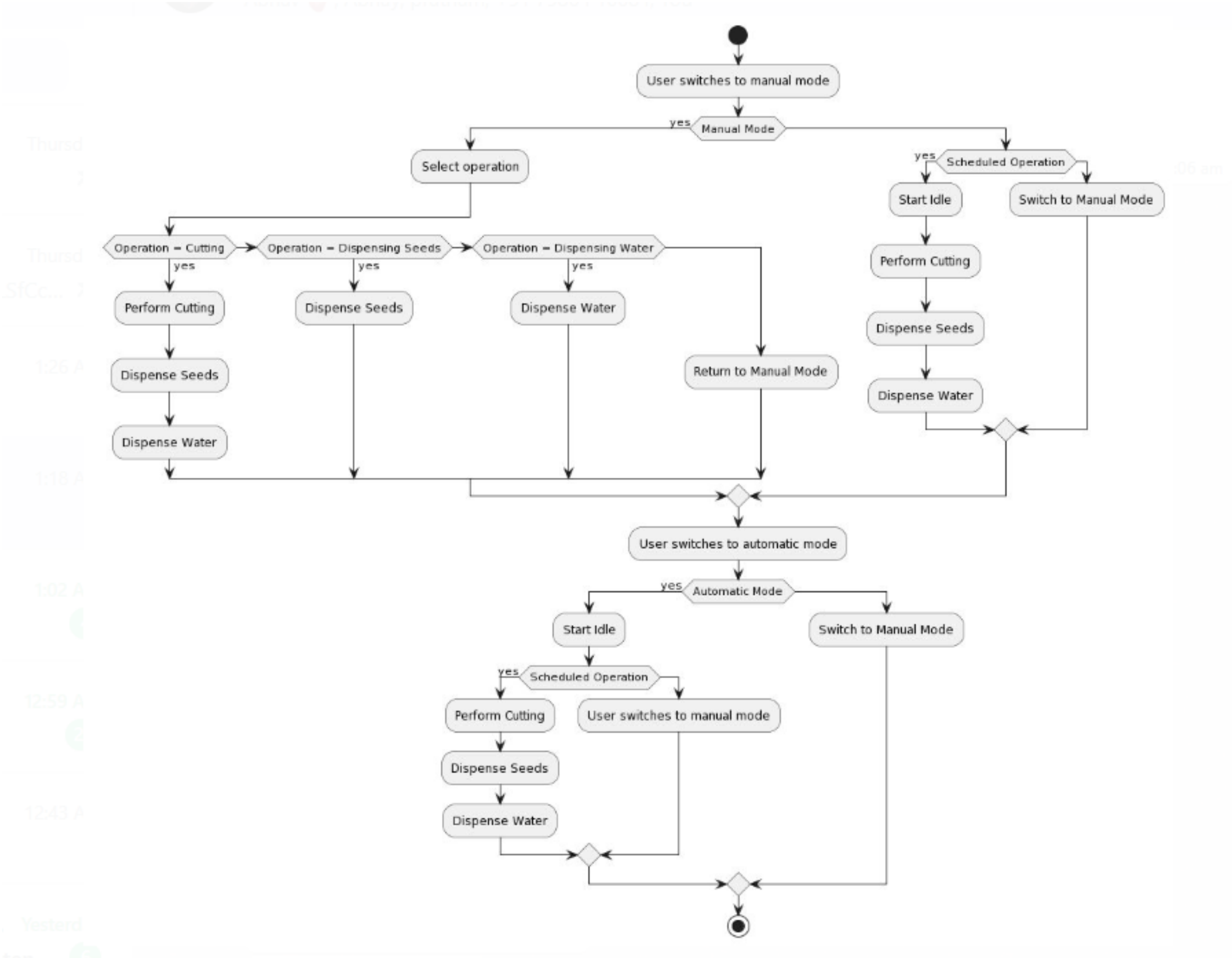
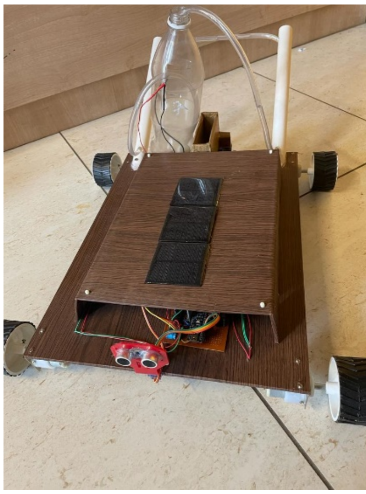
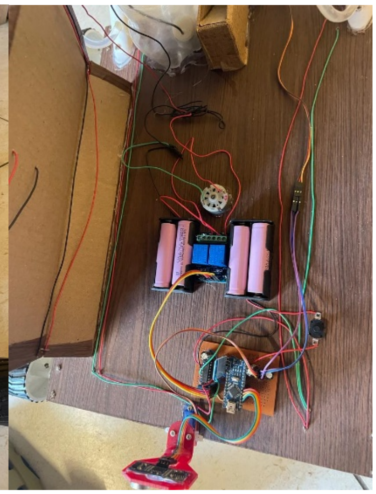


FIGURE 10: Activity Diagram

Here, we have depicted the Activity Diagram form LawnGenie which is a special type of State Chart Diagram. It is basically quite similar to a flowchart which represents the flow from one activity to another activity. These flows can be sequential, branched, or concurrent depending on what the activity is and what caused it.

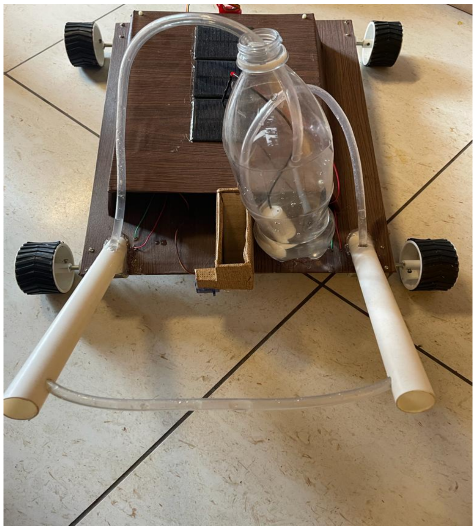
4.4 Snapshots of working prototype

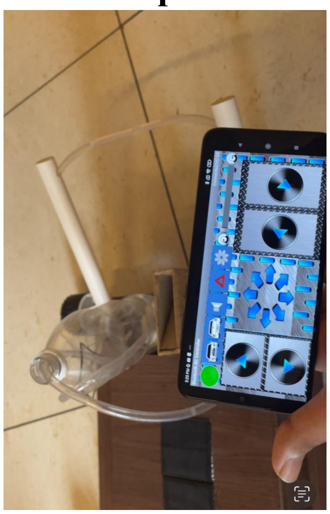




Overall structure. **Arduino board**

Seed dispenser mechanism


Water dispenser mechanism


Mobile app

5.1 WORK ACCOMPLISHED

Successful creation of a versatile robotic system featuring manual and automatic operational modes.

Seamless transition between manual and automatic modes, providing users with flexibility and convenience.

Integration of advanced functionalities including grass cutting, water dispensing, seed dispensing, and more.

Cutting-edge water dispenser intelligently irrigates the lawn, promoting optimal growth while conserving water resources.

5.2 Conclusions

Automated partially solar-powered grass-cutting machines have the potential to revolutionize lawn mowing. To minimize costs and accelerate adoption, these systems must incorporate modern technologies and concepts.

Specifically, it is important to transition from mechanical and hardware-based systems to complex electronic machinery, such as LawnGenie. This requires a systematic design plan and rigorous training and testing.

The following are some of the key considerations for designing and implementing automated partially solar-powered grass-cutting machines:

The machine must be able to operate efficiently in a variety of weather conditions, including rain, snow, and wind.

It must be able to navigate uneven terrain and obstacles, such as rocks, trees, and flower beds.

It must be able to detect and avoid people and animals.

It must be able to return to its charging station when needed.

It must be easy to use and maintain.

In addition to these considerations, the machines could also be equipped with sensors to collect data on the lawn, such as the height of the grass and the presence of weeds. This data could be used to optimize the mowing process. The machines could also be connected to a cloud-based platform, which would allow users to monitor and control them remotely. Additionally, the machines could be used to collect data on the environment, such as air quality and pollen levels. This data could be used to improve air quality and allergy management.

The development of automated partially solar-powered grass-cutting machines is still in its early stages, but it has the potential to revolutionize the way we think about lawn care. These machines could make lawn mowing a more efficient, convenient, and environmentally friendly task.

5.3 Environmental, Economic and Social Benefits

- **Environmental Benefits**

  Based on the research and analysis we have done; it is clear that the solutions currently on the market are subpar and do little to lessen the burden already being placed on the environment.

  Our brand-new, technologically superior design will benefit both the environment and our customers since it makes use of a renewable source of energy for its working and also does not produce additional waste. In addition to relieving the customer of their lawn-mowing duties, LawnGenie will help lessen environmental and noise pollution.

  The purpose of this concept is to provide a more ecologically friendly alternative to the common and harmful fuel-powered lawnmower. In the end, consumers will labour less in their everyday lives and contribute more to the environment.

- **Economic Benefits**

  In addition to the actual labour cost, countless other costs can be mitigated by implementing our solution. LawnGenie is significantly more economically viable as compared to the automated lawn mowers that are available. It is created utilising readily available, simple to use, practical, effective, and efficient tools and technology.

- **Social Benefits**

LawnGenie is a solution that is not intended to be owned and utilized only by people with higher incomes. We have made an effort to design an easily accessible, economically sound, and cost-effective solution for everyone. Anyone who believes that mowing the grass is a chore can utilise this system. It serves as a one-stop shop for anyone and everyone.

5.4 Future Work Plan

Enhancements can be made to the current system in order to make it more efficient and effective than it already is. The following features can be added in the future in order to enhance LawnGenies's capabilities and performance:

- Integrate the YOLOv8 object detection module into the hardware of LawnGenie
- Expand the obstacle dataset to improve the performance of the YOLO module so that LawnGenie can detect obstacles in every scenario. This will convert our simple object detection algorithm to a more refined algorithm.
- Improve the physical design of LawnGenie in order to make it more secure and compact
- Expand the environments and weather conditions within which LawnGenie can be operated by making it more resistant to adverse conditions
- Work on the building docking areas to recharge LawnGenie
- Integrating the running module to build a unified framework
- Work on optimizing the time and space complexity of the project.
- Other sensors can also be appended to record other necessary and relevant data

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