VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Machhe, Belagavi, Karnataka-590018

A Project Report [18CSP83]

On

"Green Sweep SunTech: Solar-Powered Grass Cutter"

Submitted in partial fulfillment of the requirements for the award of the degree of

Bachelor of Engineering

in

Information Science & Engineering

Submitted by

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DEPARTMENT OF INFORMATION SCIENCE & ENGINEERING

(Accredited by NBA, New Delhi, Validity 01.07.2023 to 30.06.2026)

GSSS INSTITUTE OF ENGINEERING & TECHNOLOGY FOR WOMEN

(Affiliated to VTU, Belagavi, Approved by AICTE, New Delhi & Govt. of Karnataka)

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Accredited with Grade "A" by NAAC

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CERTIFICATE

Certified that the 8^{th} Semester Project titled **"Green Sweep SunTech: Solar-Powered Grass Cutter**" is a bonafide work carried out by **Ananya B Dalapathi (4GW20IS002), Megha K Prasad (4GW20IS029), Nagaveni S (4GW20IS032) and Punya K (4GW20IS041)** in partial fulfilment for the award of degree of Bachelor of Engineering in **Information Science & Engineering** of the Visvesvaraya Technological University, Belagavi, during the year 2023-24. The Project report has been approved as it satisfies the academic requirements with respect to the project work prescribed for Bachelor of Engineering Degree.

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ABSTRACT

This project introduces a novel approach to lawn maintenance by combining solar power and Internet of Things (IoT) technology in the design of the Solar-Powered Grass Cutter. Traditional gas-powered lawn mowers contribute to environmental degradation and resource depletion, necessitating eco-friendly alternatives. The proposed device utilizes a dual-axis solar panel to capture solar energy and store it in a battery, while IoT connectivity enables remote control via mobile devices. Additionally, it offers a ploughing function for land preparation. Through this integration, the project aims to provide a sustainable, energy-efficient, and environmentally friendly solution for lawn care, emphasizing its contribution to advancing sustainable practices in the field.

The development of the Solar-Powered Grass Cutter revolved around key technological components: the dual-axis solar panel, battery storage system, IoT connectivity, and the integration of grass cutting and plowing functions. Initial stages focused on designing and optimizing the dual-axis solar panel to efficiently capture solar energy throughout the day. Simultaneously, the battery storage system was engineered to store the harvested energy for prolonged operation. The implementation of IoT connectivity enabled seamless remote control and monitoring via mobile devices, enhancing user convenience and accessibility. Furthermore, meticulous attention was given to the design and functionality of the grass cutting and ploughing mechanisms to ensure effective lawn maintenance and land preparation for grass cultivation.

Through the integration of solar power and IoT technology, this project aims to provide a sustainable, energy-efficient, and environmentally friendly solution for lawn maintenance. The report discusses the motivation, development process, features, and potential benefits of the Solar-Powered Grass Cutter, highlighting its contribution to advancing sustainable practices in lawn care.

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CHAPTER 1

INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 Overview

Our project endeavors to address the critical need for sustainable and energy-efficient solutions in the realm of lawn maintenance. Traditional gas-powered lawn mowers present significant environmental challenges, including pollution and resource depletion, underscoring the urgency for eco-conscious alternatives. In response, we have embarked on the development of a pioneering Solar-Powered Grass Cutter, seamlessly integrated with Internet of Things (IoT) technology.

At the core of our innovation lies the utilization of solar energy as a clean and renewable power source. The Solar-Powered Grass Cutter features a sophisticated dual-axis solar panel that efficiently captures solar energy from various angles throughout the day. This energy is stored in a high-capacity battery, ensuring uninterrupted operation and minimizing dependence on fossil fuels.

Key to the functionality of our device is its IoT connectivity, enabling remote control via mobile devices. This allows users to effortlessly manage their lawn maintenance tasks from anywhere, optimizing efficiency and convenience. Furthermore, the grass cutter's additional plowing feature facilitates land preparation for grass cultivation, enhancing its versatility and utility.

Throughout the project, our objectives are multifaceted: to develop a cutting-edge Solar-Powered Grass Cutter, to significantly reduce environmental impact through sustainable practices, to promote energy efficiency, and to enhance user experience. By conducting thorough evaluations and comparisons with conventional mowers, we aim to validate the performance and effectiveness of our solution, paving the way for broader adoption of eco-friendly technologies in lawn care.

In summary, our project is not merely about innovation; it is about redefining the future of lawn maintenance by embracing sustainability and environmental responsibility. Through the creation and implementation of the Solar-Powered Grass Cutter, we strive to empower individuals and communities to embrace greener practices and contribute to a healthier planet.

1.2 Existing System

- Conventional gas-powered lawn mowers are widely used for grass cutting.
- These mowers rely on fossil fuels for operation, contributing to pollution and resource depletion.
- Limited efficiency in capturing solar energy or utilizing renewable power sources.
- Lack of remote-control capabilities for convenient operation.
- Absence of additional features for land preparation or versatile lawn maintenance tasks.
- Overall, the existing system falls short in terms of sustainability, energy efficiency, and user convenience, highlighting the need for innovation in lawn care technology.

1.3 Proposed System

Our proposed system introduces a revolutionary approach to lawn maintenance with the development of a Solar-Powered Grass Cutter integrated with Internet of Things (IoT) technology. Unlike traditional gas-powered mowers, our system harnesses clean and renewable solar energy to power its operations, significantly reducing environmental impact. The incorporation of IoT connectivity allows for remote control capabilities via mobile devices, enhancing user convenience and optimizing lawn maintenance routines. Additionally, the inclusion of a plowing feature aids in land preparation for grass cultivation, further increasing the system's versatility and utility. Through the integration of solar power and IoT technology, our proposed system offers a sustainable, energy-efficient, and user-friendly solution to traditional lawn maintenance practices, contributing to a greener and healthier environment.

1.4 Objectives of the Proposed System

This project aims to develop a solar-powered grass cutter integrated with Internet of Things (IoT) technology, providing a sustainable and energy-efficient solution for lawn maintenance.

- To develop an efficient sun-tracking solar panel system with integrated energy storage capabilities.
- To develop an automated grass-cutting machine for lawn maintenance.
- To develop a weed-remover that works well to prepare the ground for growing grass.

- To achieve cost-efficiency by utilizing solar energy.
- To develop an eco-friendly product.

1.5 Justification of the Project

The development of our Solar-Powered Grass Cutter integrated with IoT technology is justified by the pressing need for sustainable and environmentally friendly solutions in lawn maintenance. Traditional gas-powered lawnmowers contribute to pollution, resource depletion, and noise pollution, highlighting the urgency for greener alternatives. By harnessing solar energy and incorporating IoT connectivity, our project aims to significantly reduce environmental impact while enhancing user convenience and operational efficiency. Additionally, the proposed system aligns with global efforts to combat climate change and promote sustainability, making it a valuable contribution to the transition towards a cleaner and more eco-friendly future.

1.6 Organization of the Report

The report is organized into various chapters and a brief description of each chapter is given.

Chapter 1 describes the overview, the existing system, the proposed system, the objectives, and the justification of the project.

Chapter 2 briefs about all the related and background works of this project.

Chapter 3 describes about all the system requirement specifications, functional, and non-functional requirements used in our project, and also system design with highlights of system architecture, flow chart, data flow diagram, and use case of the system.

Chapter 4 consists of the project implementation, circuit diagrams and code snippets.

Chapter 5 includes different types of testing required for the project and test cases that are designed and conducted and their corresponding outcomes.

Chapter 6 includes the snapshots of the project, followed by conclusion and future works.

CHAPTER 2

LITERATURE SURVEY

CHAPTER 2

LITERATURE SURVEY

2.1 Related Work

[1] Awan, M. A. R., Sofwan, A. S., & Multi, A. (2024). Two-Axis Solar Panel Tracking Device Prototype with Iot-Based Monitoring. ***International Journal Science and Technology*, *3*(1), 13-24.**

In this paper, the proposed project focuses on developing a two-axis sun tracker using Arduino Uno as the main controller. For its implementation, four light-sensitive resistors (LDRs) are used to detect sunlight and maximum light intensity. Two servo motors are used to move the solar panel according to the direction of sunlight detected by the LDRs. Furthermore, an ESP8266 WIFI device is used as an intermediary between the device and the IoT monitoring system.

[2] Muthukumar, P., Manikandan, S., Muniraj, R., Jarin, T., & Sebi, A. (2023). Energy efficient dual-axis solar tracking system using IOT. Measurement: Sensors, 28, 100825.

P. Muthukumar et al proposed the development of a dual-axis solar tracking system using IoT to optimize energy output from solar panels. It includes gathering data on the sun's angle of incidence, designing and developing the solar tracker, using a microcontroller to control the panel's position, and monitoring the system's performance through IoT. The developed model aims to address the need for an efficient dual-axis solar tracker system to maximize the performance of a PV panel.

[3] Aditi Singh, Durgesh Kumar Pandey, Mohd Saif Sayyed, Pratibha Dubey (2023). Solar Powered Automatic Grass Cutter. International Research Journal of Modernization in Engineering Technology and Science.

Aditi Singh et al presented the grass cutter equipped with UNO, ultrasonic sensor, DC motors, soil moisture sensor module, L293Ds, IR sensor, and Node MCU. Node MCU is used as a secondary microcontroller for fire detection data transmission. The ultrasonic sensor detects obstacles and triggers direction changes based on threshold distance. The developed model with features like obstacle detection and fire extinguishing mechanisms enhance safety. Autonomous operation ensures efficient grass-cutting without human intervention.

[4] Bhaskar, Y. B. N. V., Sabitha, T., Sahithi, P., Ramya, T., Sri, U. D., & Praseeda, P. Fully Automated Solar Grass Cutter using IoT (2023). International Journal of Innovative Science and Research Technology.

Y. B. N. V. Bhaskar et al developed the project based on the requirements including Arduino Uno, Node MCU, ultrasonic sensor, motor driver, solar panel, DC motor, battery, and IoT application. The developed project was able to send real-time data to the ThingSpeak cloud and the user was able to monitor and control the system remotely using the IoT application.

[5] Dr. N. Sambasiva Rao, Mr. Edukondalu, Bhanu Prakash, T. Vijay Rathna Kumar, G. Chandu, P.Durga Prasad, M.Sunny (2023). Integration of Weed Detection Technology into a Solar Powered Grass Cutter. International Research Journal of Progressive Research in Engineering Management and Science.

In this paper, the proposed project involves the integration of weed detection technology into a solar-powered grass cutter. This integration includes the use of high-resolution cameras on the grass cutter for real-time weed identification, supported by advanced computer vision algorithms and image processing techniques to accurately.

[6] Shang H, Shen W (2023). Design and Implementation of a Dual-Axis Solar Tracking System. Energies. ;16(17):6330.

Huilin Shang et al designed a model that involved experimental measurements to verify the efficiency increase for solar energy with the designed system. A continuous test was conducted for 5 days at the Shanghai Institute of Technology, China. The solar panels were tested outdoors, and data was collected using a multimeter connected to a data logger and computer. The developed solar tracking system showed higher energy output compared to the fixed panel during the daytime. The solar radiation power of both panels increased from morning to noon and decreased in the afternoon. Experimental data confirmed the theoretical predictions of energy collection efficiency.

[7] Sharma, P. K., Jangid, R., Yadav, N. K., & Bhatt, R. (2023). Mobile Controlled Esp32 Two-Wheel Drive Robot. *PRATIBODH*, (NCFTME 2023).

Pavan Kumar Sharma et al developed smartphone-controlled robot car that is structured using Arduino and ESP32. The mobile controlled robot basically aimed at eliminating the limitations of rang. The locomotion of robot in different directions can be controlled and manoeuvred by pressing the assigned keys on the phone. It can move forward, back, right, left, and doesn't need Bluetooth. The robot will be controlled via Wi-Fi using your ESP32-CAM.

[8] Kok, C. L., Nadaison Saravanan, S., Selvaraj, O., & Koh, Y. Y. A Multi-Threaded Real Time Operating System based Robotic Car.

In this paper, the proposed robotic car can move via user interface such as android application. It enables the user to control the car in any direction they want the car to move. The speed of the prototype is approximately 5km/h and the torque is 0.45Nm. A real-time operating system is implemented as the firmware design to create threads for each of the different tasks to make sure that all the tasks can meet their deadline. The prototype has a battery life of up to 10 hours.

[9] Kumbhar, S. Y., Patil, A., Patil, D., Gatade, A., & Khot, S. (2023). IOT based solar powered Grass cutting machine with Bluetooth remote controlling App and height adjustment mechanism using microcontroller.

In this paper, the IOT based solar powered grass cutting machine is one of the robotic vehicles. It is operated on battery and battery is energized by solar panel. This system requires 12volt battery for giving power to robotic vehicle movement as well as grass cutter motor. The working principle of grass cutter and machine motor is completely controlled by microcontroller. It controls working of all motors. In this project Bluetooth technology is used for controlling the robotic vehicle.

[10] Jemisha, F., Jothi, S. S., Priyanka, R. S., & Ramola, E. (2023). Smart Solar Agriculture Grass Cutting Robot. ***Mediterranean Journal of Basic and Applied Sciences (MJBAS)*, *7*(2), 41-47.**

The proposed project is Robotic grass cutter driven by solar energy and using Arduino. In this paper, an Arduino UNO microcontroller serves as the device's brain by managing every aspect of operation. Rechargeable batteries that are charged by a solar panel are used as the power source to power the model. The Bluetooth Module is used to track the movements of the robotic grass mower. It keeps an eye on the motor all the time and feeds data to a blink application for remote monitoring through a Wi-Fi module. A DC motor is observed using Node MCU. The motor driver regulates the DC motor's rotational speed and direction.

2.2 Literature Survey Summary

A literature survey represents a study of previously existing material on the topic of the report. This includes existing theories about the topic which are accepted universally. Paper written on the topic are both generic and specific. Research done in the field usually in the order of oldest to Challenges being faced and ongoing work, if available.

Table 2.1: Literature Survey Summary

SL NO.	TITLE	AUTHOR	METHODOLOGY	REFERENCES	YEAR
01	Two-Axis Solar Panel Tracking Device Prototype with IoT-Based Monitoring	M.Asep Rizkiawan, Agus Sofwan, Abdul Multi	This project focuses on developing a two-axis sun tracker using Arduino Uno as the main controller. For its implementation, four light-sensitive resistors (LDRs) are used to detect sunlight and maximum light intensity. Two servo motors are used to move the solar panel according to the direction of sunlight detected by the LDRs. Furthermore, an ESP8266 WIFI device is used as an intermediary between the device and the IoT monitoring system.	International Journal Science and Technology	2024
02	Energy efficient dual-axis solar tracking system using IoT	P.Muthukumar, S. Manikandan R. Muniraj, T.Jarin, Ann Sebi	It involves the development of a dual-axis solar tracking system using IoT to optimize energy output from solar panels. It includes gathering data on the sun's angle of incidence, designing and developing the solar tracker, using a microcontroller to control the panel's position, and monitoring the system's performance through IoT.	ResearchGate June 2023	2023
03	Solar Powered Automatic Grass Cutter	Aditi Singh, Durgesh Kumar Pandey, Mohd Saif Sayyed, Pratibha Dubey Kola Snigdha, Bhavana Sai Priya, Shresta, Sindhuja, P.	Grass cutter equipped with UNO, ultrasonic sensor, DC motors, soil moisture sensor module, L293Ds, IR sensor, and Node MCU. Node MCU is used as a secondary microcontroller for fire detection data transmission. The ultrasonic sensor detects obstacles and triggers direction changes based on threshold distance.	International Research Journal of Modernization in Engineering Technology and Science	2023

		Hari Krishna			
04	Fully Automated Solar Grass Cutter using IoT	Y. B. N. V. Bhaskar, T. Sabitha, P. Sahiti, T. Ramya, U. Dhanya Sri, P. Praseeda	Designed based on project requirements including Arduino Uno, Node MCU, ultrasonic sensor, motor driver, solar panel, DC motor, battery, and IoT application Thingspeak cloud.Developed using Arduino IDE to enable automatic grass-cutting functionality.	International Research Journal of Modernization in Engineering Technology and Science, 2023	2023
05	Integration of Weed Detection Technology into a Solar Powered Grass Cutter	Dr. N. Sambasiva Rao, Mr. Edukondalu, Bhanu Prakash, T. Vijay Rathna Kumar, G. Chandu, P. Durga Prasad, M.Sunny	It involves the integration of weed detection technology into a solar-powered grass cutter. This integration includes the use of high-resolution cameras on the grass cutter for real-time weed identification, supported by advanced computer vision algorithms and image processing techniques to accurately.	International Research Journal of Progressive Research in Engineering Management and Science, 2023	2023
06	Design and implementation of a Dual-Axis Solar Tracking System	Huilin Shang , Wei Shen	It involved experimental measurements to verify the efficiency increase for solar energy with the designed system. A continuous test was conducted for 5 days at the Shanghai Institute of Technology, China. The solar panels were tested outdoors, and data was collected using a multimeter connected to a data logger and computer.	MDPI Journal doi.org/10.3390/en16176330	2023
07	Mobile Controlled Esp32 Two-Wheel Drive Robot	Pawan Kumar Sharma, Rohit Jangid, Nand Kishor Yadav, Rohit Bhatt, Dayal, Singh rathore	The proposed project is smartphone-controlled robot car that is structured using Arduino and ESP32. The mobile controlled robot basically aimed at eliminating the limitations of rang. The locomotion of robot in different directions can be controlled and manoeuvred by pressing the assigned keys on the phone. It can move forward, back, right, left, and doesn't need Bluetooth. The robot will be controlled via Wi-Fi using your ESP32-CAM.	Pratibodh, A Journal for Engineering	2023
08	A Multi-Threaded Real Time	Chiang Liang Kok, Nadaison Saravanan	The proposed robotic car can move via user interface such as android application. It enables the user to control the car in any direction they	The International Journal of Engineering and Science	2023

	Operating System based Robotic Car	S/O Selvaraj, Yit Yan Koh	want the car to move. The speed of the prototype is approximately 5km/h and the torque is 0.45Nm. A real-time operating system is implemented as the firmware design to create threads for each of the different tasks to make sure that all the tasks can meet their deadline. The prototype has a battery life of up to 10 hours.		
09	IOT based solar powered Grass cutting machine with Bluetooth remote controlling App and height adjustment mechanism using microcontroller	Sagar Y. Kumbhar, Apeksha Patil, Dipti Patil, Aishwarya Gatade, Sonali Khot	The IOT based solar powered grass cutting machine is one of the robotic vehicle. It is operated on battery and battery is energized by solar panel. This system requires 12volt battery for giving power to robotic vehicle movement as well as grass cutter motor. The working principle of grass cutter and machine motor is completely controlled by microcontroller. It controls working of all motors. In this project Bluetooth technology is used for controlling the robotic vehicle.	International Research Journal of Engineering and Technology	2023
10	Smart Solar Agriculture Grass Cutting Robot	F.Jemisha, S. Siva Jothi, R. Siva Priyanka & E. Ramola	Robotic grass cutter driven by solar energy and using Arduino. In this paper, an Arduino UNO microcontroller serves as the device's brain by managing every aspect of operation. Rechargeable batteries that are charged by a solar panel are used as the power source to power the model. The Bluetooth Module is used to track the movements of the robotic grass mower. It keeps an eye on the motor all the time and feeds data to a blink application for remote monitoring through a Wi-Fi module. A DC motor is observed using Node MCU. The motor driver regulates the DC motor's rotational speed and direction.	Mediterranean Journal of Basic and Applied Sciences	2023
11	Revolutionizing Appliance Automation: ESP32 And Bynk	Helen Grace Gonzales	The "Automated System for Appliances Using ESP32 and Blynk Application" offers a flexible and userfriendly interface, distinguishing it from other automation systems. This system integrates mobile devices into the automated setup,	Research Gate	2023

			comprising a Bluetooth/Wi-Fi module, ESP32 microcontroller, and relay circuits. The communication between the Android phone and the ESP32 microcontroller occurs through Wi-Fi, enabling efficient utilization of the limited display space on mobile devices.		
12	Real Time Monitoring Small Scale Off Grid Solar System with Blynk App	AnnaMalar Salvan, Mohd Fadly Abd Razak	This research project aims to address the need for a monitoring system specifically designed for small solar grid systems. The project focuses on developing a user-friendly monitoring system utilizing the Arduino ESP32 microcontroller and the Blynk software. The system employs optimized data collection methods and error management systems to ensure stability and reliability. The collected data is securely transmitted to the Blynk app, enabling users to remotely monitor their solar power installations in real-time. The Blynk software offers visual representations such as measurements and graphs, facilitating data interpretation and analysis.	Progress in Engineering Application and Technology	2023
13	IOT Based Solar Grass Cutting Robot	Ch. Bhanu Sri, Sk. Khaja Mohiddin, S. Naresh Kumar, V. Mohan Kalyan, A. Veer Raju, K. Nagendra Prasad, U. Sai Mohan	IoT-based solar grass cutting robots involves collecting data from sensors, processing the data using algorithms, and using actuators to carry out the required action. The robot is able to navigate the lawn, detect obstacles, and adjust its cutting height based on the density and height of the grass. In addition, the IoT-based solar grass cutting robot is also equipped with a communication module, which enables it to connect to the internet and communicate with other devices. This communication module allows the robot to receive commands and send status updates to a remote server or a mobile application.	International Journal for Multidisciplinary Research (IJFMR)	2023
14	A Blynk Controlled Solar Powered Golf Grass Cutter	Muhamad Fairus Mohd Nor, Dur Muhammad Soomro	This project describes the development of an IoT-based smart grass cutter for golf courses using the Blynk platform. The microcontroller is connected to the Blynk platform, which allows for remote control and monitoring of the grass cutter. The system also includes user interface	Evolution in Electrical and Electronic Engineering	2023

			access through the Blynk app, which allows for easy control and monitoring of the grass cutter. The system also includes a power management circuit that manages the power from the solar panel and the battery.		
15	Smart Hybrid Fully Automatic Solar Grass Cutter	Shradha Sharad Meghpuje, Hrithik Kisan Lokhande, Nilesh Dadaso Patil, Shahrukh Salim Makandar, A.C. Daiv	The proposed project has the solar panel is mounted on the grass cutter machine receives the solar power from the sun. This solar power stored in the battery. The working principle of solar grass cutter is it has panels mounted in a particular arrangement at frame that it can receive solar radiation with high intensity easily from the sun. The solar panels convert solar energy into electrical energy, using photovoltaic effect and stored in battery. The main function of the solar charge controller is to increase the current from panels while batteries power-driven by solar energy. It also detects the obstacles in the path based on that changes the movement direction.	International Journal for Multidisciplinary Research	2023
16	Solar Based Grass Cutter	Avantika Sonalikar, Aditya Bhoyar, Ritik Pardhi, Vivek Patil, Vaibhav Mohile, Satnam Tandekar	Solar powered grass cutter comprises of direct current (D.C RS775) motor, a rechargeable battery, solar panel, a stainless steel blade and control switch. The solar powered grass cutter is operated by the switch on the board which closes the circuit and allows the flow of current to the motor which in turn drive the blade used for mowing. The battery recharges through the solar charging controller.	International Journal Of Progressive Research In Engineering Management And Science	2023
17	Smart Phone Controlled Solar Grass Cutter Robot using Bluetooth	P. Krishna Chaitanya, N. Swathi Kiranmai, N. Vijaya Sankar, Y. Harshitha, M. Mukesh, M. Satya Vinay	The fully 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 of any human interaction. The system uses batteries to power the vehicle movement motors as well as the grass cutter motor. Solar panel is used to charge the battery. The grass cutter and vehicle motors are interfaced to Arduino family microcontroller that controls the working of all the motors. The robotic movements like forward, backward, left, right and	International Journal for Advanced Research in Science and Technology	2023

			stop will be controlled from the mobile app using Bluetooth technology.		
18	A Light Weight Solar Powered Lawn Mower	Shivam Yadav, Dinesh Kumar, Naveen Kumar, Indra Kr. Pal, Dipanarayan Kushwaha, Saurav Yadav	The lawn mower has a 360-degree rotating panel arrangement in such a way that it can receive a high intensity of solar radiation from sun. The solar panels convert solar energy into electrical energy, the electrical energy get stored in a rechargeable battery. when switch is on, circuit get closed and it allow the current to flow in the dc motor, the dc motor can be adjusted to considerable length it can be manually adjusted up to 5 cm, the supply of power from the battery is given to the dc motor, the shaft of dc motor start rotating with which stainless steel blade is coupled, which has very sharp edge it also starts rotating with the shaft and cut the grass at an even length.	International Journal Of Advanced Research and Innovative Ideas in Education	2022
19	Solar Grass Cutter	Dr. P. S. Chaudhari, Sanchit J. Mhashakhetri, Achal R. Panchbhai, Aman V. Kadu, Sachin S. More, Jatin Rahangdale	The solar grass cutter project involves utilizing solar energy as the primary power source for the grass-cutting robot. The system integrates 12V batteries to power the car's moving engines and the lawn mower, with a solar panel for battery charging. Control of the lawnmowers and cars is achieved through a Mobile Phone and Arduino system .	International Journal of Advanced Research in Science, Communication and Technology, 2022	2022
20	Solar-Based Weed or Grass-Plucking Robot	Ragam Prathyusha, Sabbani Sai Pavan, Koyda Sai Kruthik, Y. Pradeep	Solar panels are arranged to receive high-intensity solar radiation, Conversion of solar energy into electrical energy by the panels. Electrical energy is stored in batteries using a solar charger.	International Research Journal of Modernization in Engineering Technology and Science, 2022	2022
21	Smart Solar-Based Grass Cutter	Dr. J. G. Chaudhari, Akash S Ingole, Aakash Z Patel, Kunal R Bhagat, Ashwini S Gaurkhede	Utilized for controlling the movement of the smart solar grass cutter. When the user inputs the garden or lawn area (e.g., 20*30 meters) through a mobile application, Arduino processes the data and sends commands to the relay to start the motor rotation for covering the specified area.	International Journal Of Advanced Research in Science, Communication, and Technology,	2022

22	IoT-Based Automatic Solar Grass Cutter with Scalable patterns	Kola Snigdha, Bhavana Sai Priya, Shresta, Sindhuja, P. Hari Krishna	The solar-based automatic grass cutter was designed and fabricated using Arduino-based bot system components. The system is powered by solar panels that convert sunlight into electricity to operate the grass cutter. Bluetooth technology is used for communication between a smartphone and the grass cutter to provide specific input on the type of pattern and dimensions for cutting.	Journal of Emerging Technologies and Innovative Research, 2022	2022
23	Solar Powered Hybrid Lawn Mower based on Arduino	Dev Khetan, Komal Rajput, Hritik Mittal	This system offers a fully automatic grass cutting system. The machine has a blade attached to it which will run at high RPM to chop the grass. The system includes sophisticated functionality that allows it to cover the whole area of a lawn or garden by employing an ultrasonic sensor to identify corners and mow the entire lawn or garden. The vehicle movement DC motors are powered by one battery, while the lawn cutter motor is powered by the other. Also, the system uses a solar panel to demonstrate the charging of the vehicle's movement battery. The micro controller operates the vehicle movement dc motors as well as the grass cutter at the same time as monitoring the ultrasonic sensors.	International Journal of Scientific and Research Publications	2021
24	Implementation of Dual Axis Solar Tracking System	V Mohanapriya, V Manimegalai, VPraveenkumar and P Sakthivel	The automated solar tracking system based on the Arduino prototype is mainly built using the Arduino Microcontroller, four LDRs and three stepper motors. A mixture of hardware and firmware programming is used to run the machine. Four light based resistors (LDRs) are used for the capture of maximum incident light in hardware production. To shift the solar panel according to the extent incident light operated by LDRs, three stepper motors are used. The software controls the solar panel's vertical tilt angle and horizontal rotation. Thus, according to the incident sunlight on the solar panel, it	IOP Conference Series: Materials Science and Engineering	2021

			can follow the direction of the Sun, not only the vertical rotation, but also the horizontal rotation.		
25	A Review of Fully Automated Grass Cutter Using Solar Power	Shubham R. Khilare, Deepak P. Morey, Bhagyashri A. Ghoti, Shaileja S.Thorat, Swapnil D. Pimple, Manmohan O.Sharma	It involves the development and evaluation of a fully automated solar grass cutter using components such as Arduino Uno, ultrasonic sensor, Bluetooth module, motor driver, DC motor, and 12V battery supply. The grass cutter is controlled by an Android application and tested under manual and automatic operational modes.	International Journal of Progressive Research in Science and Engineering, July-2020	2020

CHAPTER 3

SYSTEM REQUIREMENTS AND DESIGN

CHAPTER 3

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3.1Requirements

3.1.1 Functional Requirements

Functional requirement defines a function of a system or its component, where a function is described as a specification of behavior between outputs and inputs. Functional requirements may involve calculations, technical details, data manipulation, processing and other specific functionality that define what a system is supposed to accomplish. The functional requirements of “Green Sweep SunTech: Solar-Powered Grass Cutter” are:

- **Solar Energy Capture:**
  - **Efficient Solar Panel:** The system shall include a dual-axis solar panel capable of efficiently capturing solar energy from various angles.
  - **Energy Conversion:** The system shall convert the captured solar energy into electrical energy for powering the grass cutter.
  - **Battery Charging:** The system shall charge the battery system with the generated solar energy to ensure continuous operation.
  - A Solar panel of 5V, an Arduino UNO microcontroller, 4 LDR’s, TP4056 charging module, 2 Servo motors with 180°, 4 resistors of 10Ω each and a rechargeable battery of 3.7 volts is used in the designing of the Solar Charging Module for the capture of solar energy.
- **IoT Connectivity:**
  - **Mobile Application Interface:** The system shall provide a user-friendly mobile application interface for remote control and monitoring of the grass cutter. Forward, Backward, Left and Right directions can be controlled.
  - **Wi-Fi Connectivity:** The system shall establish a reliable Wi-Fi connection between the grass cutter and the user's mobile device for seamless communication.
  - **Real-Time Feedback:** The system shall provide real-time feedback to the user regarding battery status.

- **Grass Cutting Functionality:**
  - **Cutting Mechanism:** The system shall include a reliable cutting mechanism. The Grass cutter is designed using Brushless DC Motor of 3000rpm, 4 blades for grass cutting, an L298N motor driver connected esp32.
  - **Efficient Operation:** The system shall ensure efficient operation of the cutting mechanism to minimize energy consumption and maximize cutting performance.
- **Ploughing Feature:**
  - **Ploughing Attachment:** The system shall include a ploughing attachment for land preparation tasks such as soil tilling. The mechanism of upward and downward movement of the plough is controlled using a servomotor.
  - **Integrated Control:** The system shall seamlessly integrate the ploughing feature with other functionalities of the grass cutter for user convenience.
- **Wi-Fi Controlled Car:**
  - **Remote Control:** The system shall allow users to remotely control the movement of the Wi-Fi controlled car using the mobile application interface.
  - **Real-Time Monitoring:** The system shall provide real-time monitoring of the Wi-Fi controlled car's status through the mobile application.
  - **Responsive Navigation:** The system shall ensure responsive navigation of the Wi-Fi controlled car, allowing for precise movement and manoeuvrability.

3.1.2 Non- Functional Requirements

Non-functional requirement is a requirement that specifies criteria that can be used to judge the operation of a system, rather than specific behaviors. They are contrasted with functional requirements that define specific behavior or functions. The main Non-functional requirements of “Green Sweep SunTech: Solar-Powered Grass Cutter” are:

- **Reliability:** The equipment should operate consistently and reliably under different weather conditions and terrains.
- **Durability:** Construction should be robust and durable to withstand extended use and environmental factors, ensuring a long product life cycle.
- **Safety:** The equipment must adhere to safety standards, including protection against accidental start-ups and safety features for user protection.
- **Scalability:** The design should allow for potential upgrades or enhancements to meet future demands or changes in technology.
- **Usability:** The product should be intuitive and user-friendly, with clear instructions and easily understandable controls.
- **Performance:** The cutting and weed removal efficiency should meet industry standards, ensuring effective grass maintenance and weed removal.
- **Environmental Impact:** It should have minimal environmental impact, producing zero emissions and noise pollution during operation.
- **Interoperability:** Compatibility with other devices or systems, potentially enabling connectivity for data exchange or software updates.
- **Regulatory Compliance:** Adherence to industry, environmental, and safety standards, meeting legal requirements and certifications.
- **Maintainability:** Ease of maintenance and repair, including access to spare parts and tools, as well as clear maintenance schedules and instructions.

3.1.3 Software Requirements

Operating System	:	Windows 10 or above
IDE	:	Arduino
IDE Language	:	Embedded C
IoT platform	:	Blynk IoT

3.1.4 Hardware Requirements

Solar panel	: 5V Solar Panel is with polycrystalline silicon solar cells.
Wheels	: 4 Wheels of 70mm Dia. x 40mm Width each
Lithium-ion Batteries	: 4 18650 3.7V 3800mAH Rechargeable Battery
Brushless DC Motor	: 12V Brushless DC Motor

Gear Motors	: 4 DC Geared Motors 30 RPM - 12V Centre Shaft
Servo Motor	: TowerPro SG90 Servo Motor, 180° Rotation
ESP 32	: ESP32 DEVKIT V1
Arduino UNO	: ATmega328 (SMD) – Interface CH340G
Motor driver	: L298N motor drivers
LDR	: 4 Light sensitive Photoresistor LDR’s
Jumper Wires	: Male-Female, Male-Male and Female-female Wires
Voltage Sensor	: Voltage Detection Sensor Module 25V
Charging Module	: TP4056 charging module
Resistors	: 4 Resistors of 10k Ω each
Bread Board	: 830 Points Solderless PCB Breadboard
Blades	: 4 blades for Grasscutter
Mounting Brackets	: 4 Center Shaft Gear Motor L Clamp
Voltmeter	: 0.56inch AC220V 2-Wire AC Voltmeter 70V ~ 500V
Battery Holder	: 3 x 1.5V AA Battery Holder

3.2 System Design

System design encompasses the detailed specification of the architecture, components, modules, interfaces, and data for a system based on the requirements outlined during system analysis. It involves translating the conceptual idea into a blueprint that guides the implementation phase. System design includes decisions on hardware, software, user interfaces, and integration methods, ensuring that the system meets functional and non-functional requirements while being scalable, maintainable, and robust.

3.2.1 System Architecture

System architecture refers to the conceptual structure and organization of a complex system, defining its components, their relationships, and how they interact to achieve the system's objectives. It encompasses both the hardware and software aspects, detailing the distribution of functionalities, data flow, and communication protocols. A well-designed system architecture ensures scalability, reliability, and maintainability while meeting the system's requirements and constraints.

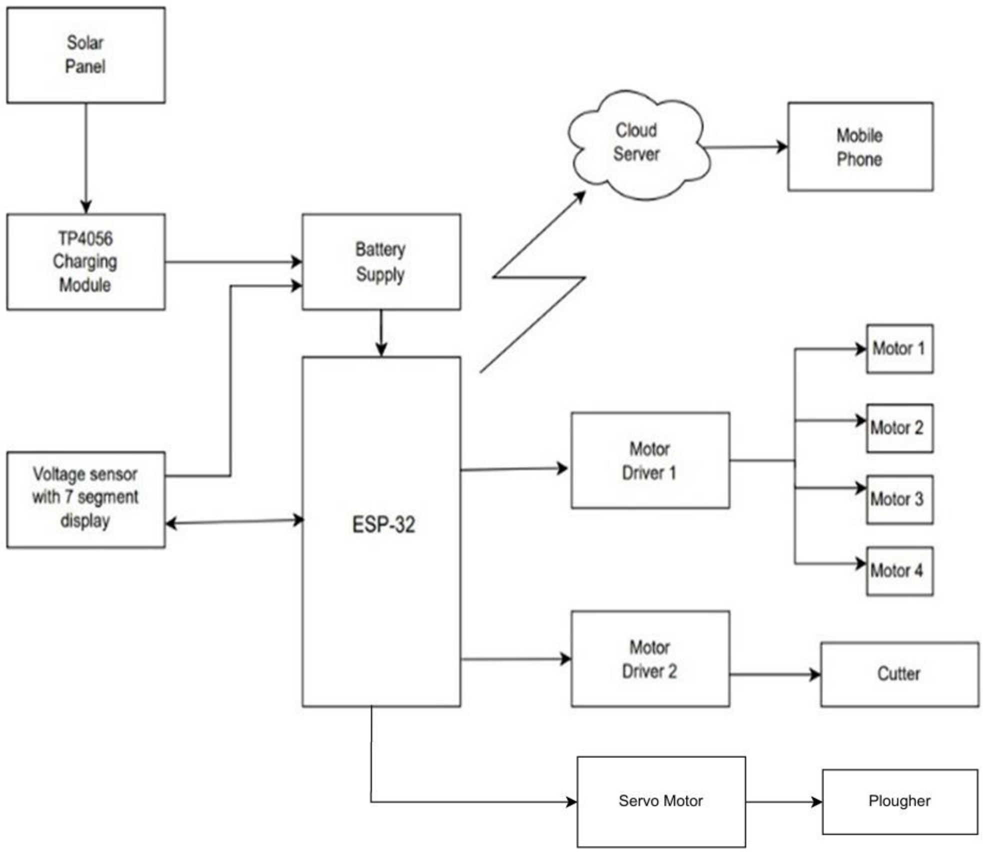

Figure 3.1: System Architecture of Solar-powered Grasscutter

Figure 3.1 represents the system Architecture of Solar-powered Grasscutter which illustrates the flow of energy from the dual-axis solar panel to the battery, and then to various components such as wheels, grass cutter, and plough through the controller. Additionally, the Blynk app is shown to control the movement of the vehicle, grass cutter, and the ploughing process.

- **Node MCU ESP32**

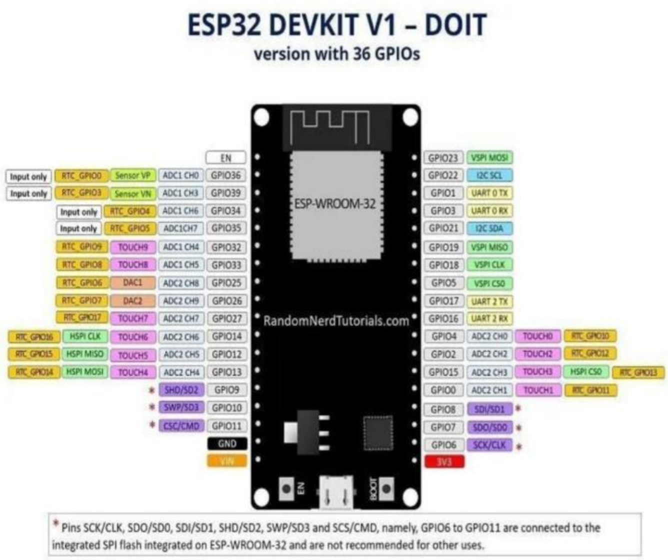

Figure 3.2: Pin Diagram of Node MCU ESP32

Figure 3.2 illustrates the pin configuration of ESP32 where the Node MCU is an open source IoT stage. It incorporates firmware running on ESP8266 Wi-Fi SoC from Espress if Systems and equipment dependent on ESP-12 modules. The expression "hub MCU" consequently alludes to firmware instead of an advancement pack.

- **L298N Motor Driver**

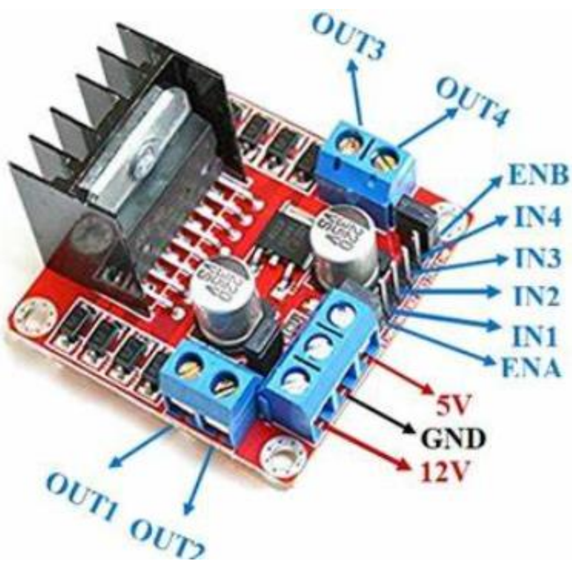

Figure 3.3: Pin Diagram of L298N Motor Driver

Figure 3.3 illustrates the L298N Motor Driver, a dual H-bridge motor driver module commonly utilized in robotics and automation projects. This module incorporates several pins crucial for interfacing with microcontrollers or control systems. The ENA and ENB pins serve as enable inputs for controlling the motor driver channels A and B, respectively, while IN1, IN2, IN3, and IN4 are utilized as input pins to determine the direction of rotation for motors connected to channels A and B. Additionally, the module features +12V and GND pins for connecting to the motor power supply and ground, respectively. These pins collectively enable precise control over motor speed and direction, making the L298N Motor Driver an integral component in various applications requiring motor control.

- **Voltage Sensor**

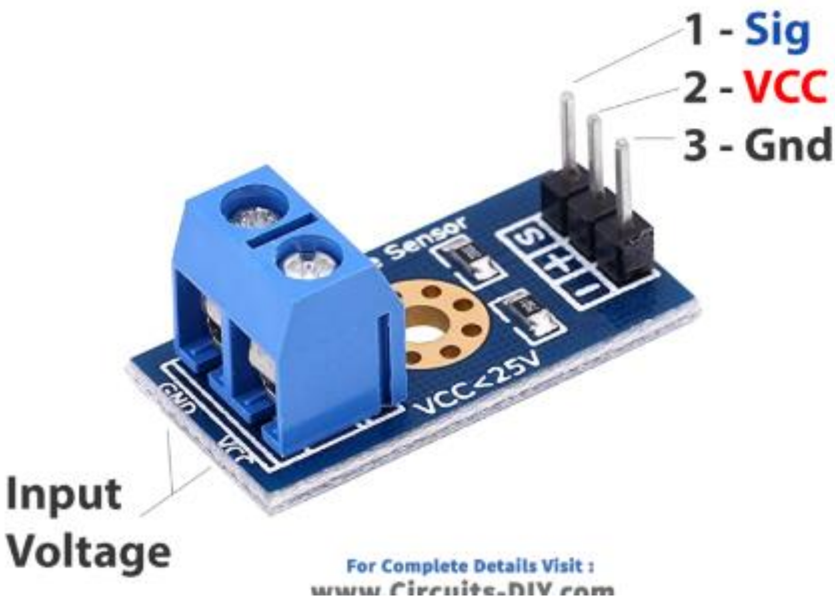

Figure 3.4: Pin Diagram of Voltage Sensor

Figure 3.4 illustrates Voltage Sensor, comprising five pins, plays a pivotal role in the circuit. Among these pins, "SIG" serves as the signal pin, facilitating the transmission of voltage level data to the ESP32 controller. "VCC" provides the sensor with the necessary power supply, ensuring its operation, while "GND" serves as the ground connection, establishing the reference point for voltage measurement. The remaining two pins are designated for input voltage, enabling the sensor to accurately measure and monitor the voltage level of the connected circuit. This comprehensive configuration allows the Voltage Sensor to effectively communicate voltage data to the ESP32 controller, facilitating precise control and monitoring of the electrical system.

- **Gear Motor**

Figure 3.5: Gear Motor

Figure 3.5 illustrates a gear motor, a key component responsible for the movement of the vehicle in the circuit. This motor operates at a speed of 30 revolutions per minute (rpm), providing the necessary torque and rotational motion to propel the vehicle forward or backward. The gear motor typically consists of a motor unit coupled with a gearbox, which helps to increase torque while reducing speed, making it suitable for driving the vehicle's wheels. This component plays a crucial role in enabling controlled and efficient movement of the vehicle within the circuit.

- **Arduino UNO**

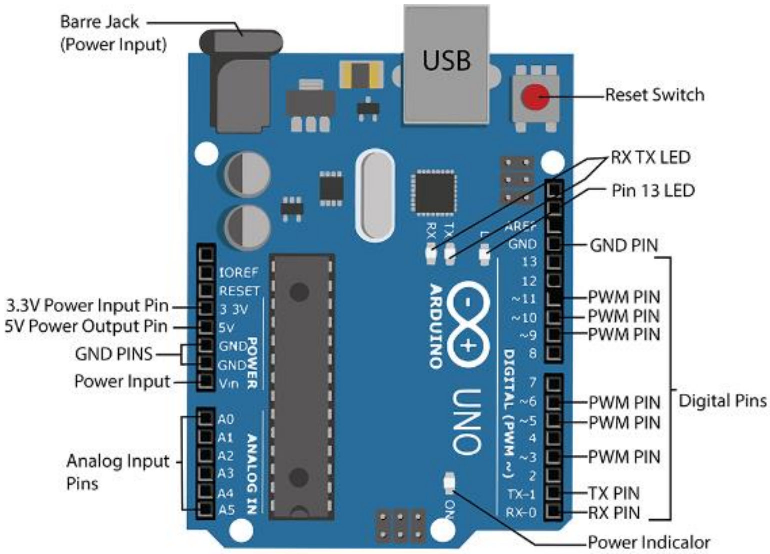

Figure 3.6: Pin Diagram of Arduino UNO

Figure 3.6 illustrates an Arduino Uno, a widely-used microcontroller board for various applications, including solar panel control. It features multiple pins serving different functions: digital pins for general-purpose input/output (GPIO), analog pins for reading analog signals such as those from sensors, power pins for supplying voltage (5V and 3.3V) and ground (GND), and communication pins (RX and TX) for serial communication. The Arduino Uno's flexible pin configuration makes it suitable for interfacing with sensors, actuators, and other components in solar panel systems, enabling monitoring, control, and optimization of solar energy generation.

- **Solar Panel**

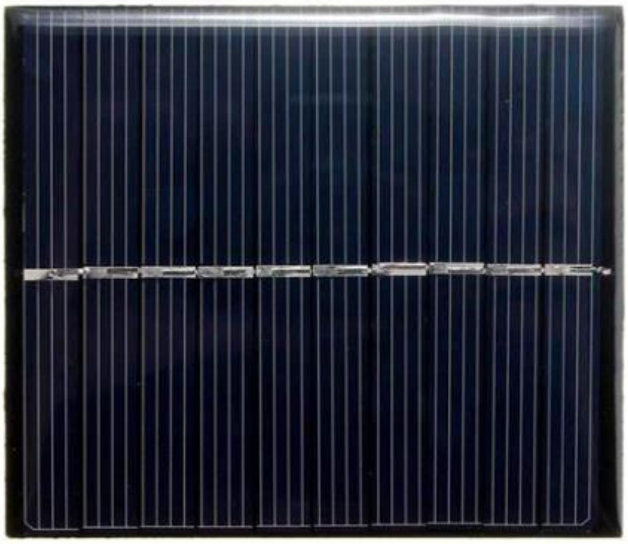

Figure 3.7: Solar Panel

Figure 3.7 illustrates a 5V solar panel, a photovoltaic module designed to convert sunlight into electrical energy. This type of solar panel typically features a photovoltaic cell array connected in series or parallel to generate a voltage output of 5 volts. It is commonly used in low-power applications where a small amount of electrical energy is required, such as charging batteries, powering small devices, or supplying voltage to microcontrollers like Arduino. The 5V solar panel offers a convenient and eco-friendly solution for harnessing solar energy in various projects and applications.

- **LDR Sensor**

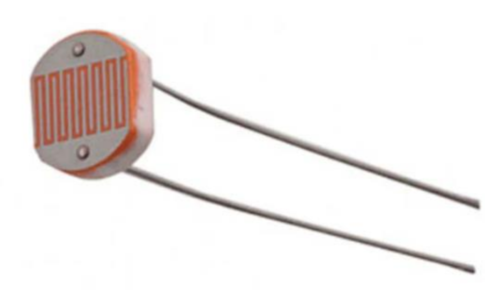

Figure 3.8: LDR Sensor

Figure 3.8 illustrates an LDR (Light Dependent Resistor) sensor, a key component in light sensing applications. This sensor's resistance varies with changes in ambient light levels, making it ideal for detecting light intensity. As light increases, the resistance of the LDR decreases, and vice versa. The sensor typically consists of two terminals for connection to a circuit, allowing it to provide analog voltage or resistance values proportional to the light incident on its surface. LDR sensors find applications in automatic lighting systems, sun tracking systems, and environmental monitoring devices.

- **Charging Module TP4056**

Figure 3.9: Charging Module TP4056

Figure 3.9 illustrates a Charging Module TP4056, a compact and versatile lithium-ion battery charging module. This module features an integrated TP4056 charging chip, which provides reliable and efficient charging for single-cell lithium-ion or lithium polymer batteries. It typically includes input and output terminals for connecting to power sources and batteries, along with status indicator LEDs to signify charging status. The TP4056 module incorporates overcharge and over-discharge protection circuits, ensuring safe and reliable charging for various portable electronic devices, such as smartphones, power banks, and IoT devices.

- **Servo Motor**

Figure 3.10: Servo Motor

Figure 3.10 illustrates a servo motor, a crucial component in dual-axis solar panel systems for precise orientation control and also used for ploughing module. This motor is tasked with adjusting the azimuth and elevation angles of the solar panel to maximize sunlight exposure throughout the day. By receiving control signals from the microcontroller, the servo motor rotates to specific angles, allowing the solar panel to track the sun's position accurately. Its compact size, high torque, and precise positional control make the servo motor ideal for applications requiring dynamic movement and accurate positioning, such as solar tracking systems.

- **Brushless DC Motor**

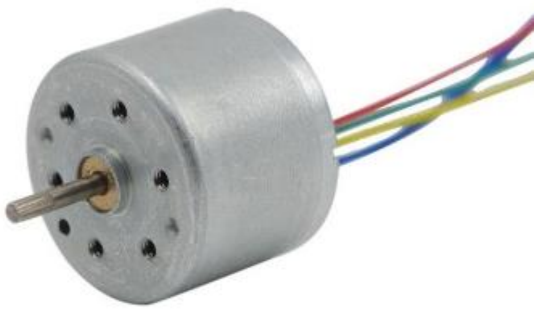

Figure 3.11: Brushless DC Motor

Figure 3.11 illustrates a Brushless DC (BLDC) Motor, a high-performance motor commonly used in grass cutters and other power tools. Unlike traditional brushed motors, BLDC motors feature electronic commutation, offering benefits such as higher efficiency, greater reliability, and lower maintenance requirements. With its ability to deliver variable speeds and high torque, the BLDC motor provides the necessary power for the grass cutter, allowing it to operate at maximum speed as needed to efficiently cut grass and vegetation. This motor's design ensures optimal performance and durability in demanding applications, making it well-suited for tasks requiring precise control and reliable operation.

3.2.2 Flowchart

A flowchart is a graphical representation of a process, algorithm, or system, using standardized symbols to depict the sequence of steps and decision points involved. It provides a visual guide that helps to understand and analyze the flow of operations, making complex processes easier to comprehend and communicate. Flowcharts are widely used in various fields such as software development, engineering, business management, and education to illustrate workflows, troubleshoot problems, and streamline processes.

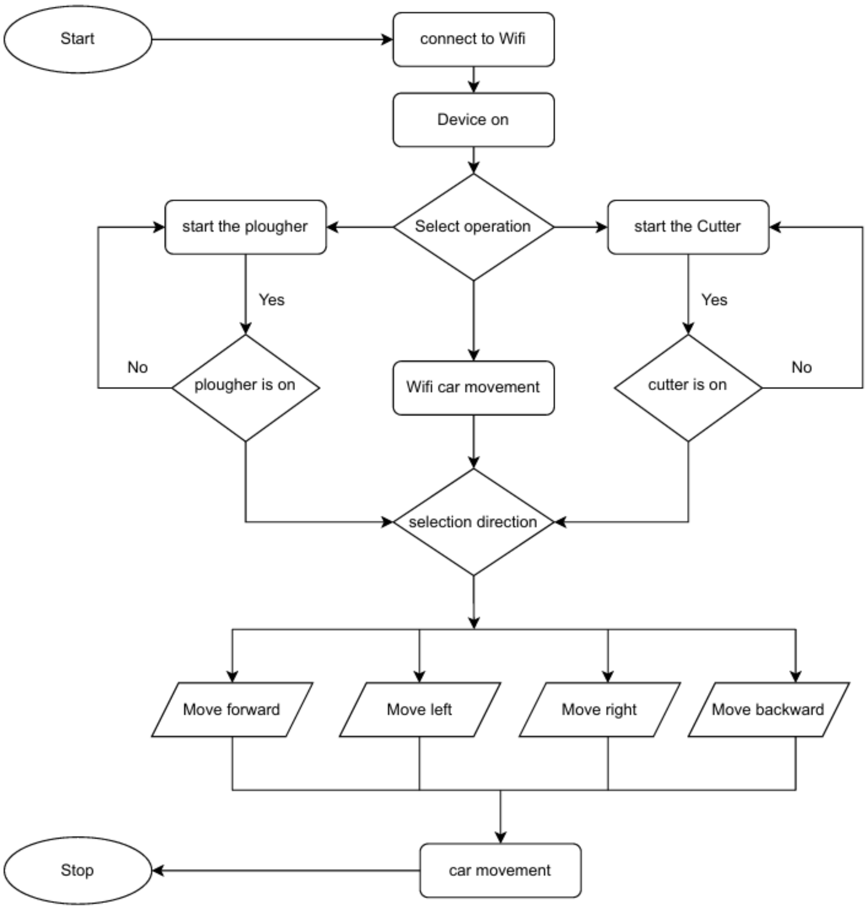

Figure 3.12: Flow chart of Solar-powered Grasscutter

Figure 3.12 is a flowchart which illustrates the sequential process of a solar-powered grass cutter system. It begins with capturing solar energy via dual-axis solar panels, storing it in a battery. The battery then supplies energy to the wheels, cutter, and plougher. Additionally, the Blynk app controls the vehicle's movement, grass cutter, and ploughing model, facilitating remote operation and management.

3.2.3 Dataflow Diagram

A dataflow diagram (DFD) is a visual representation that illustrates the flow of data within a system. It depicts how data moves through various processes, from input to output, showing the interactions between different components of the system. DFDs use symbols to represent data sources, processes, data stores, and data flows, providing a clear and concise overview of information flow and transformations within a system, which aids in understanding system functionalities and identifying potential bottlenecks or inefficiencies.

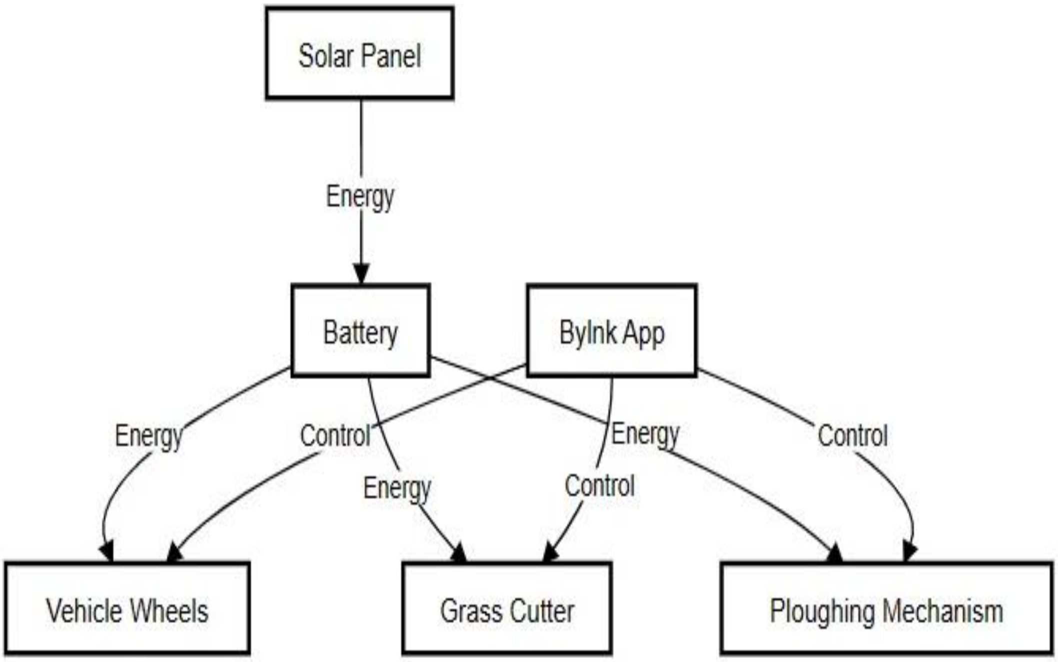

Figure 3.13: Dataflow Diagram of Solar-powered Grasscutter

Figure 3.13 is the dataflow diagram represents the flow of energy from the solar panels to the battery and then to the various components of the grass cutter (wheels, cutter, and plougher). Additionally, the Blynk app is used to control the movement of the vehicle, grass cutter, and ploughing model.

3.2.4 Use Case Diagram

A use case diagram is a visual representation that depicts the interactions between users (actors) and a system to achieve specific goals or functionalities. It illustrates the various use cases or scenarios of how users interact with the system to accomplish tasks, demonstrating the system's functionalities from a user's perspective. Use case diagrams help in understanding system requirements, identifying actors and their roles, and clarifying the relationships between different functionalities, thereby aiding in system design and communication between stakeholders.

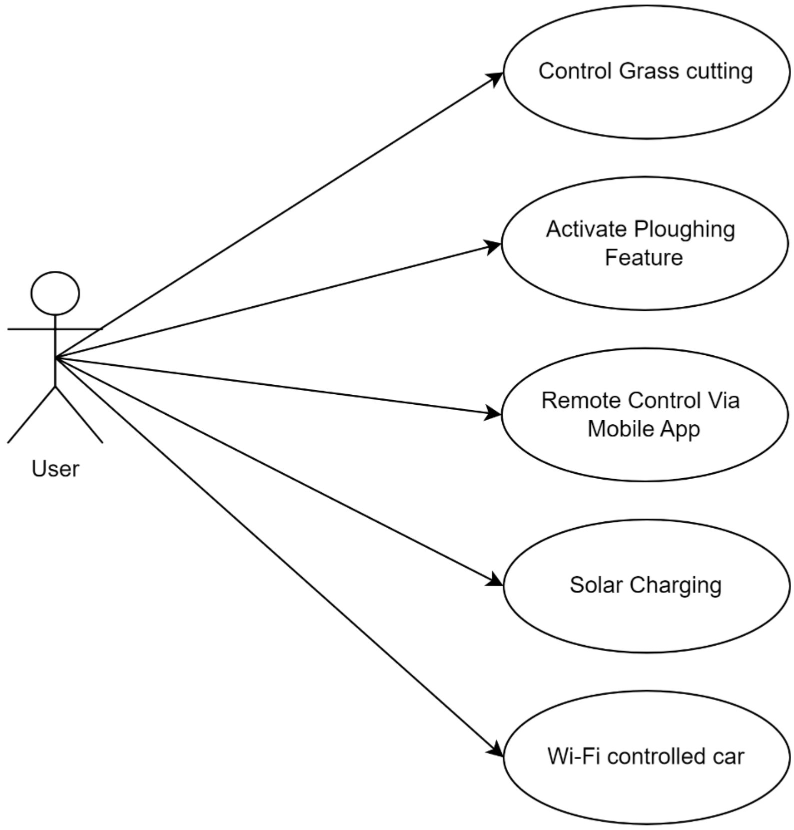

Figure 3.14: Use Case Diagram of Solar-powered Grasscutter

Figure 3.14 use case diagram is given for the solar-powered grass cutter system, various factors such as "User," "Blynk App," and "Solar Panel" interact with the system. Use cases include "Control Vehicle Movement," "Control Grass Cutter," and "Control Ploughing Model." These use cases demonstrate how users and external systems engage with the grass cutter, leveraging functionalities like energy storage from solar panels and battery, and remote control through the Blynk app for efficient operation and maintenance.

- **Use Case Diagram for Grass Cutter Module**

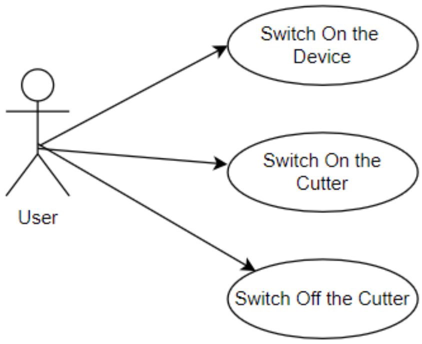

Figure 3.15: Use Case Diagram of Grasscutter Module

Figure 3.15 illustrates a Use Case Diagram for the Grass Cutter Module, depicting the interaction between users and the device via the Blynk app. The primary use cases include "Switch On Device" and "Switch On/Off Cutter." In the "Switch On Device" scenario, the user initiates the grass cutter module by activating the device through the Blynk app, which sends a signal to power on the system. Once the device is powered on, the user can utilize the "Switch On/Off Cutter" functionality to control the cutting mechanism. By toggling the respective button on the Blynk app, the user can activate or deactivate the cutter, enabling efficient grass cutting operations. This Use Case Diagram illustrates the seamless integration between user interaction via the Blynk app and device functionality, allowing for convenient and intuitive control of the grass cutter module.

➢ **Use Case Diagram for Ploughing Module**

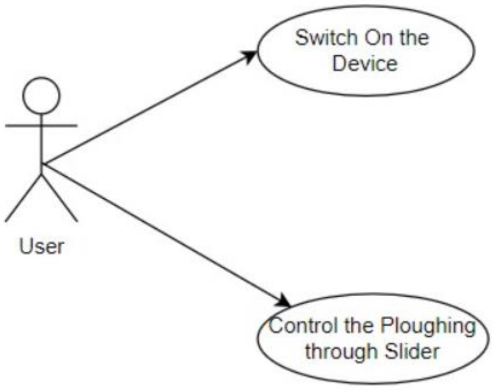

Figure 3.16: Use Case Diagram of Ploughing Module

Figure 3.16 illustrates a Use Case Diagram for the Ploughing Module, outlining user interactions with the device through the Blynk app. The primary use cases include "Switch On Device" and "Control Plougher." In the "Switch On Device" scenario, the user activates the ploughing module via the Blynk app, triggering the device to power on. Once the device is powered on, the user can utilize the "Control Plougher" functionality to adjust the ploughing depth and angle. By adjusting the slider on the Blynk app, the user can precisely control the plougher, ensuring optimal performance during the ploughing process. This Use Case Diagram demonstrates the seamless integration between user input through the Blynk app and device functionality, facilitating efficient and user-friendly control of the ploughing module.

CHAPTER 4

IMPLEMENTATION

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IMPLEMENTATION

4.1 Implementation Approaches

The Solar-Powered Grass Cutter is a sophisticated device comprising several key components to ensure efficient operation. These components include solar panels, microcontrollers, motor drivers, motors (such as gear motors, servo motors, and DC motors), blades, and rechargeable batteries. The gear motors are responsible for driving the wheels, enabling movement in various directions, while servo motors are utilized to adjust the position of the solar panels for optimal sunlight capture. Meanwhile, the DC motor drives the cutting mechanism, spinning the cutting blades to trim grass effectively. To control these motors, the L298N Motor Driver is employed, with one unit managing wheel movement and the other controlling the grass cutter.

Two microcontrollers, namely the ESP32 and Arduino UNO, serve as the central processing units of the device. The ESP32 is programmed to control the motors for both wheels and cutter blades, as well as manage Wi-Fi communication for remote control and monitoring. On the other hand, the Arduino UNO is tasked with controlling the movement of the solar panels to maximize solar energy absorption. Rechargeable batteries are utilized to store the harvested solar energy, ensuring uninterrupted operation of the grass cutter. The battery level is monitored and relayed to the Blynk cloud for remote monitoring, allowing users to stay informed about the device's power status. Additionally, a dual-axis solar panel is employed to optimize solar energy capture, while a TP4056 charging module indicates when the battery is fully charged. This comprehensive setup ensures efficient and sustainable operation of the solar-powered grass cutter, enhancing its usability and effectiveness.

4.2 Circuit Diagrams

➢ **Circuit Diagram of ESP32**

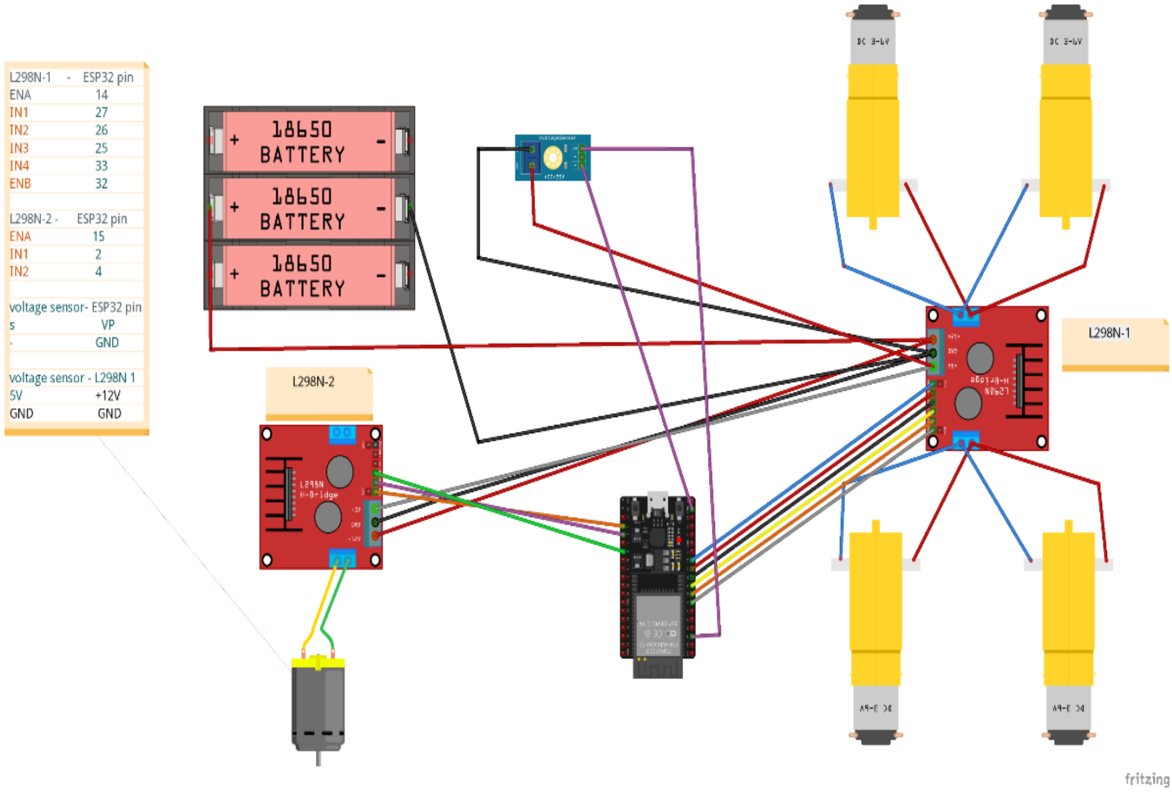


Figure 4.1: Circuit Diagram of Grass Cutter

Figure 4.1 illustrates the circuit connection between an ESP32 controller, an L298N motor driver module (L298N-1 and L298N-2), and a voltage sensor. The ESP32 pins ENA, IN1, IN2, IN3, IN4, and ENB are connected to corresponding pins on L298N-1 and L298N-2, facilitating motor control. The voltage sensor's positive (5V) and negative (GND) terminals are connected to the ESP32's VP and GND pins, respectively. Additionally, the L298N-1 is powered by +12V and GND connections. The Blynk app interfaces with the ESP32, enabling remote control of the vehicle, grass cutter, and ploughing process.

- **Circuit Diagram of Arduino UNO**

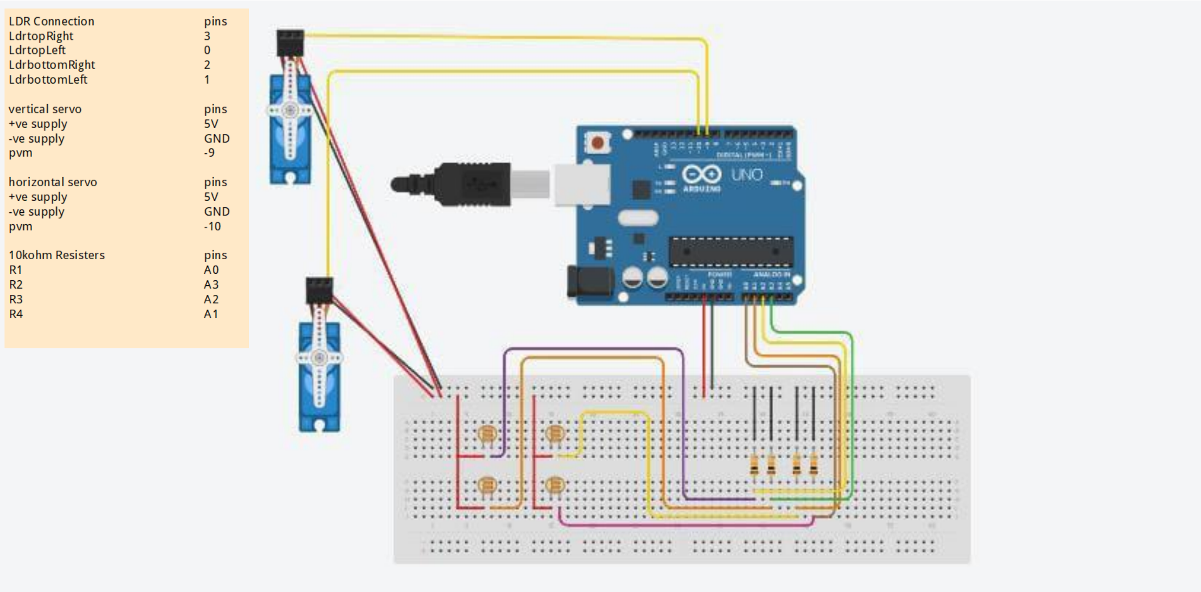


Figure 4.2: Circuit Diagram of Solar panel

Figure 4.2 illustrates circuit diagram outlines the connections between various components and the Arduino Uno controller for a solar panel tracking system. The LDRs (Light Dependent Resistors) at each corner of the solar panel detect light intensity, with each LDR connected to a specific analog pin on the Arduino (LdrTopRight - A3, LdrTopLeft - A0, LdrBottomRight - A2, LdrBottomLeft - A1). The vertical servo motor, responsible for adjusting the solar panel's vertical angle, connects to pins +5V, GND, and pin 9 (PWM). Similarly, the horizontal servo motor, controlling the panel's horizontal movement, connects to +5V, GND, and pin 10 (PWM). Additionally, 10kohm resistors (R1, R2, R3, R4) connect to analog pins A0-A3, serving as voltage dividers for accurate LDR readings. Overall, this setup enables the Arduino to monitor light levels through LDRs and adjust the solar panel's position accordingly for optimal energy collection.

4.3 Code Snippet

Arduino UNO solar panel connectivity

```
#include <Servo.h>
Servo servohori; //horizontal servo(BOTTOM SERVO)
int servoh = 0; //assign servo at 0 degree
int servohLimitHigh = 180;
int servohLimitLow = 10
```

```
Servo servoverti;
int servov = 0;
int servovLimitHigh = 180;
int servovLimitLow = 10;

int ldrtopr = 3; //top right LDR A1 pin
int ldrtopl = 0; //top left LDR A2 pin

int ldrbotr = 2; // bottom right LDR A0 pin
int ldrbotl = 1; // bottom left LDR A3 pin

 void setup ()
 {
        servohori.attach(10); //horizontal servo connected to arduino pin 10
        servohori.write(0);

        servoverti.attach(9); //vertical servo connected to arduino pin 9
        servoverti.write(0);
        delay(500); //delay
 }
void loop()
{
        servoh = servohori.read();
        servov = servoverti.read();
        int topl = analogRead(ldrtopl); //read analog values from top left LDR
        int topr = analogRead(ldrtopr); //read analog values from top right LDR
        int botl = analogRead(ldrbotl); //read analog values from bottom left LDR
        int botr = analogRead(ldrbotr); //read analog values from bottom right LDR
        int avgtop = (topl + topr) / 2; //average of top LDRs
        int avgbot = (botl + botr) / 2; //average of bottom LDRs
        int avgleft = (topl + botl) / 2; //average of left LDRs
        int avgright = (topr + botr) / 2; //average of right LDRs

        if (avgtop < avgbot)
        {
                servoverti.write(servov -1);
                if (servov > servovLimitHigh)
                 {
                        servov = servovLimitHigh;
                 }
                delay(8);
        }
        else if (avgbot < avgtop)
        {
                servoverti.write(servov +1);
                if (servov < servovLimitLow)
               {
                      servov = servovLimitLow;
               }
                delay(8);
```

```
        }
        else
        {
                servoverti.write(servov);
        }

        if (avgleft > avgright)
        {
                servohori.write(servoh -1);
                if (servoh > servohLimitHigh)
                {
                        servoh = servohLimitHigh;
                }
                delay(8);
        }
        else if (avgright > avgleft)
        {
                servohori.write(servoh +1);
                if (servoh < servohLimitLow)
                 {
                        servoh = servohLimitLow;
                 }
                delay(8);
        }
        else
        {
                servohori.write(servoh); // write means run servo
        }
        delay(50);
}
```

ESP32 Wi-Fi Controlled Device

```
#define BLYNK_PRINT Serial
#include <WiFi.h>
#include <WiFiClient.h>
#include <BlynkSimpleEsp32.h>

#include <Wire.h>
//Motor PINs
#define ENA 14
#define IN1 27
#define IN2 26
#define IN3 25
#define IN4 33
#define ENB 32
#define ENC 15
#define IN5 2
#define IN6 4
// Define analog input
#define ANALOG_IN_PIN A0
```

```
bool forward = 0;
bool backward = 0;
bool left = 0;
bool right = 0;
bool on=0;
bool voltage = 0 ;
int Speed=200;
char auth[] = "Zg8UGv-6jLybuN09lDu1sXZ1-WY_3t-X"; //Enter your Blynk application
auth token
char ssid[] = "Dala"; //Enter your WIFI name
char pass[] = "ga0t@123"; //Enter your WIFI passowrd

// Floats for ADC voltage & Input voltage
float adc_voltage = 0.0;
float in_voltage = 0.0;

// Floats for resistor values in divider (in ohms)
float R1 = 30000.0;
float R2 = 7500.0;

// Float for Reference Voltage
float ref_voltage = 3.5;

// Integer for ADC value
int adc_value = 0;

void setup() {
            Serial.begin(9600);
            pinMode(ENA, OUTPUT);
            pinMode(IN1, OUTPUT);
            pinMode(IN2, OUTPUT);
            pinMode(IN3, OUTPUT);
            pinMode(IN4, OUTPUT);
            pinMode(ENB, OUTPUT);
            pinMode(ENC, OUTPUT);
            pinMode(IN5, OUTPUT);
            pinMode(IN6, OUTPUT);
            Blynk.begin(auth, ssid, pass, "blynk.cloud", 80);
}
BLYNK_WRITE(V0) {
        forward = param.asInt();
}
BLYNK_WRITE(V1) {
            backward = param.asInt();
}
BLYNK_WRITE(V2) {
        left = param.asInt();
}
BLYNK_WRITE(V3) {
        right = param.asInt();
```

```
}
BLYNK_WRITE(V4) {
        on = param.asInt();
}
void smartcar() {
    if (forward == 1) {
        carforward();
        Serial.println("carforward");
    } else if (backward == 1) {
        carbackward();
        Serial.println("carbackward");
    } else if (left == 1) {
        carturnleft();
        Serial.println("carfleft");
    } else if (right == 1) {
        carturnright();
        Serial.println("carright");
    }  else if (forward == 0 && backward == 0 && left == 0 && right == 0) {
        carStop();
        Serial.println("carstop");
    }
    {
     if (on == 1) {
         carblade();
         Serial.println("carblade");
     }
     else{
          carbladeoff();
          Serial.println("carbladestop");
     }
    }
}
void loop()
{
    adc_value = analogRead(ANALOG_IN_PIN);
    // Determine voltage at ADC input
    adc_voltage  = (adc_value * ref_voltage) / 4095.0;
    // Calculate voltage at divider input
    in_voltage = adc_voltage*(R1+R2)/R2;
    int Per = (in_voltage/12) * 100;
    Serial.print("Input Voltage = ");
    Serial.println(in_voltage, 2);
    Serial.print("Battery Percentage:");
    Serial.print(Per);
    Serial.println("%");
    delay(500);
   Blynk.virtualWrite(V5, Per);
    Blynk.run();
    smartcar();
}
```

```
void carforward() {
        analogWrite(ENA, Speed);
        analogWrite(ENB, Speed);
        digitalWrite(IN1, LOW);
        digitalWrite(IN2, HIGH);
        digitalWrite(IN3, LOW);
        digitalWrite(IN4, HIGH);
}
void carbackward() {
        analogWrite(ENA, Speed);
        analogWrite(ENB, Speed);
        digitalWrite(IN1, HIGH);
        digitalWrite(IN2, LOW);
        digitalWrite(IN3, HIGH);
        digitalWrite(IN4, LOW);
}
void carturnleft() {
        analogWrite(ENA, Speed);
        analogWrite(ENB, Speed);
        digitalWrite(IN1, LOW);
        digitalWrite(IN2, HIGH);
        digitalWrite(IN3, HIGH);
        digitalWrite(IN4, LOW);
}
void carturnright() {
        analogWrite(ENA, Speed);
        analogWrite(ENB, Speed);
        digitalWrite(IN1, HIGH);
        digitalWrite(IN2, LOW);
        digitalWrite(IN3, LOW);
        digitalWrite(IN4, HIGH);
}
void carblade() {
        digitalWrite(ENC, HIGH);
        digitalWrite(IN5, LOW);
        digitalWrite(IN6, HIGH);
}
void carStop() {
        digitalWrite(IN1, LOW);
        digitalWrite(IN2, LOW);
        digitalWrite(IN3, LOW);
        digitalWrite(IN4, LOW);
}
void carbladeoff() {
        digitalWrite(IN5, LOW);
        digitalWrite(IN6, LOW);
}
```

CHAPTER 5

TESTING

CHAPTER 5

TESTING

5.1 System Testing

Testing is a process of executing a program to ensure that defined input will produce actual results that agree with required outputs. In developing a software project, error can be initiated at any stage during the development. For each phase of the software development cycle there are different techniques for detecting and elimination errors that originate in that phase. However, some errors will reflect in the code. Testing performs a very crucial role for quality assurance and for ensuring the reliabilities of the software. The quality of the system depends on its design, development, testing and implementation. Weaknesses in any of these areas will seriously affect the quality and therefore value of the system to its users. Once the code has been generated, testing of the modules begins implementation ends with formal tests.

These include:

- Development cost of the program is reduced.
- Assuring that the application behaves exactly as we explain to user For the majority of programs, unpredictability is the least desirable consequences of using an application. The total cost of ownership is reduced. By providing software that looks and behaves as shown in the documentation, fewer hours of training and less support from product experts is sufficient for customers. Developing customer loyalty. System testing is the process of checking the objective and requirements. It is a very critical element of software quality assurance (SQA) and represents the review of specification, design and coding. Testing represents an interesting anomaly i.e deviation from what is actually required for the software. Thus, a series of tests are performed for the proposed system before the system is ready for customer acceptance. Some of the various test cases used to test the system are as follows:
    - The test cases are written for testing against requirements of the unit being tested.
    - If the unit modifies the database, test for the integrity of the database.
    - Test cases for the path or branch coverage should be done.
    - Test cases for data flow coverage should be done.

5.2 Test Classification

- **Unit Testing**

Unit testing focuses verification on the smallest unit of software design, the software component or module. Using the component level design description as a guide, important control paths are tested to uncover errors within the boundary of the module. The unit testing is a white box- oriented testing. First of all, the module interface is tested to ensure that the information properly flows into and out of the program until under test. Then the local data structure is tested to ensure the data stored temporarily maintains its integrity during all steps in an execution. Boundary conditions are tested to ensure that the module operates properly at boundaries established to limit or restrict processing.

All independent paths through the control structure are exercised to ensure that all statements in a module have been executed at least once. And finally, all errors handling paths are tested. In this project the testing is done according to bottom-up approach. Starting with smallest and lowest level modules and processing one at a time. For each module a driver and corresponding stubs were also written. If any errors found they were corrected immediately and the unit was tested again.

Unit testing for the solar-powered grass cutter involves systematically testing each individual component or unit of the system to ensure its functionality and reliability in isolation. This includes testing the solar panel controller's ability to accurately track the sun's position and optimize energy capture, verifying the efficiency of the battery management system in charging and discharging the battery, and assessing the IoT connectivity module's stability and responsiveness in facilitating remote control and monitoring. Additionally, the grass cutting and plowing mechanisms are tested for effectiveness and reliability in their respective tasks,

- **Integration Testing**

Integration testing is a logical extension of unit testing. In its simplest form, two units that have already been tested are combined into a component and the interface between them is tested. A component, in this sense, refers to an integrated aggregate of more than one unit. Integration testing (sometimes called integration and testing, abbreviated I&T) is the phase in software testing in which individual software modules are combined and tested as a group. Integration testing is conducted to evaluate the compliance of a system or component with specified functional requirements. It occurs after unit testing and before system testing. Integration testing takes as its input modules that have been unit tested, groups them in larger aggregates, applies tests defined in an integration test plan to those aggregates, and delivers as In big-bang testing, most of the developed modules are coupled together to form a complete software system or major part of the system and then used for integration testing. This method is very effective for saving time in the integration testing process. However, if the test cases and their results are not recorded properly, the entire integration process will be more complicated and may prevent the testing team from achieving the goal of integration testing.

A component, in this sense, refers to an integrated aggregate of more than one unit. The idea is to test combinations of pieces and eventually expand the process to test your modules with those of other groups. Eventually all the modules making up a process are tested together. Any errors discovered when combining units are likely related to the interface between units. This method reduces the number of possibilities to a far simpler level of analysis. In this software, the bottom- up integration testing approached has been used, starting with the smallest and lowest level modules and proceeding one at a time. For each module the tests were conducted and the results were noted down.

- **User Testing**

  User Testing is nothing but the test of the software by the users themselves with live data being fed to the system. This helps in building really robust system. User testing in this system has been done extensively ascertain the results.

- **Purpose of Testing**

  Testing accomplishes a variety of things, but most importantly it measures the quality of the software we are developing. This view presupposes there are defects in the software waiting to be discovered and this view is rarely disproved or even disputed. Several factors contribute to the importance of making testing a high priority of any software development effort. These include:

  - Reducing the cost of developing the program.

- Ensuring that the application behaves exactly as we explain to the user for the vast majority of programs, unpredictability is the least desirable consequences of using an application.
- Reducing the total cost of ownership.
- By providing software that looks and behaves as shown in the documentation, the customers require fewer hours of training and less support from product experts.

Testing is a process of evaluating the functionality, correctness, and quality of a software application or system. It involves executing various test cases and scenarios to identify defects, errors, or inconsistencies in the software. The purpose of testing is to ensure that the software meets the desired requirements, functions as expected, and performs reliably in different scenarios. Testing helps identify and fix issues before the software is deployed or released, thereby improving its overall reliability and user satisfaction. Testing Part takes with the two steps one is testing with positive scenarios and another is with testing with negative scenarios.

- **Functional Testing**

  Functional Testing is a testing technique that is used to test the features/functionality of the system or Software, should cover all the scenarios including failure paths and boundary cases. Functional testing for the solar-powered grass cutter involves thoroughly testing its features and functionalities to ensure they operate as intended across various scenarios. This encompasses validating the grass cutting function's efficacy in different grass types and heights, verifying the plowing function's effectiveness, and testing the remote control functionality via the mobile app for seamless communication and responsiveness.

- **System Testing**

  System Testing is usually carried out by a team that is independent of the development team in order to measure the quality of the system unbiased. It includes both functional and Non-Functional testing. System testing for the solar-powered grass cutter encompasses a holistic evaluation of the integrated system to ensure functionality, performance, and compliance with both functional and non-functional requirements. This entails rigorous testing of features such as grass cutting, plowing, and remote control via the mobile app to verify proper operation.

- **White Box Testing**

  White box testing is a testing technique that examines the program structure and derives test data from the program logic/code. The other names of glass box testing are clear box testing, open box testing, logic driven testing or path driven testing or structural testing. White box testing for the solar-powered grass cutter involves a meticulous examination of its internal structure and code to ensure thorough coverage of all functionalities and potential vulnerabilities. This comprehensive testing process includes a code review to assess adherence to coding standards and best practices.

- **Black Box Testing**

  Black-box testing is a method of software testing that examines the functionality of an application based on the specifications. It is also known as Specifications based testing. Black box testing for the solar-powered grass cutter involved evaluating its functionality and performance without considering internal structure. Various tests include providing different sunlight levels to verify optimal energy utilization, testing remote control via a mobile app for prompt responsiveness, evaluating the plowing function's effectiveness on different soil types, simulating diverse weather conditions to ensure operational resilience, and monitoring battery performance for efficient charging and discharging. These tests aim to validate the device's reliability, functionality, and user-friendliness under various real-world scenarios, ensuring its effectiveness in sustainable lawn maintenance.

5.3 Test Cases

Table 5.1: Test cases

Sl No.	Description	Expected Results	Actual Results	Status (Pass/Fail)
TC01	ESP32 Wi-Fi Connectivity Test	ESP32 successfully	Connected	Pass
TC02	Arduino UNO Solar Panel Control Test	Arduino UNO adjusts Solar panel based on LDR input	Panel moves	Pass
TC03	Motor Driver (L298N) Functionality	Motor driver Successfully controls	Motors operate	Pass

	Test	Gear motors		
TC04	Dual-Axis Solar Panel Movement Test	Solar panel moves Horizontally and vertically	Panel moves as set	Pass
TC05	LDR (Light Dependent Resistor) Calibration Test	LDR accurately measures sunlight intensity	Gives correct readings	Pass
TC06	Battery Charging Test	Charging module charges battery from solar panel	Battery is charging	Pass
TC07	Grass Cutting Functionality Test	DC motor activates and cuts grass	Grass is cut	Pass
TC08	Mobile App Connection Test	Mobile app Successfully communicates with device	App connected	Pass
TC09	App Dashboard Display Test	Mobile app displays real-time device status	Dashboard updated	Pass
TC10	Overall System Integration Test	All components work together for Autonomous operation	System functions	Pass

CHAPTER 6

RESULTS AND DISCUSSION

CHAPTER 6
RESULTS AND DISCUSSION

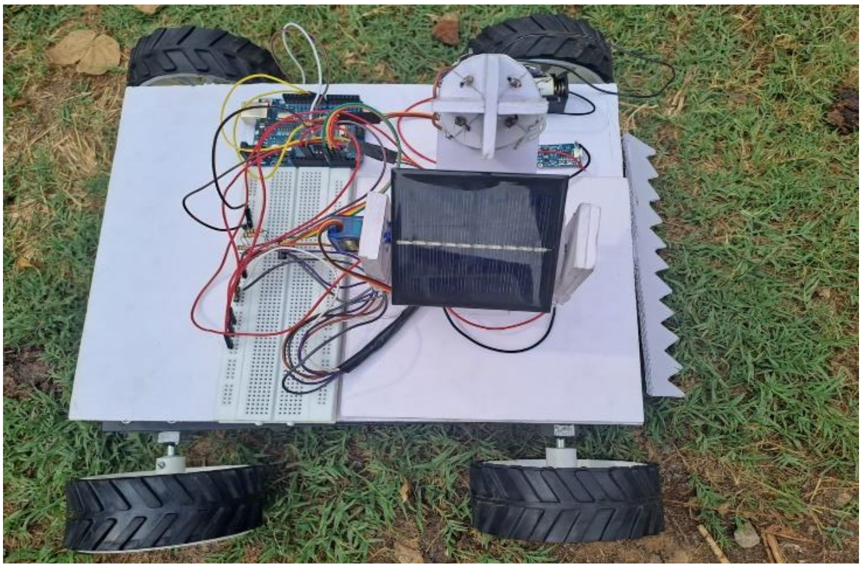
6.1 Snapshots

Snapshot 6.1: Sun tracking

Snapshot 6.1 shows the full working of the Solar Panel when exposed to Sunlight. The Panel tilts towards the side where the high intensity sunlight falls.

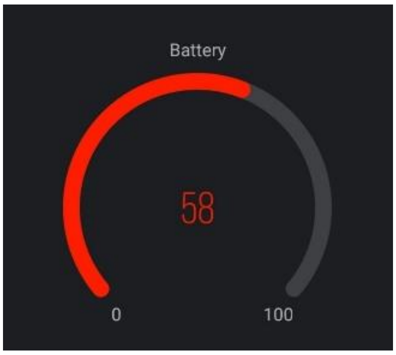
Snapshot 6.2: Side view of grass cutter

Snapshot 6.2 shows the side view of the grass cutter, in which the cutter attached to the shaft of the dc motor to cut the grass is visible.



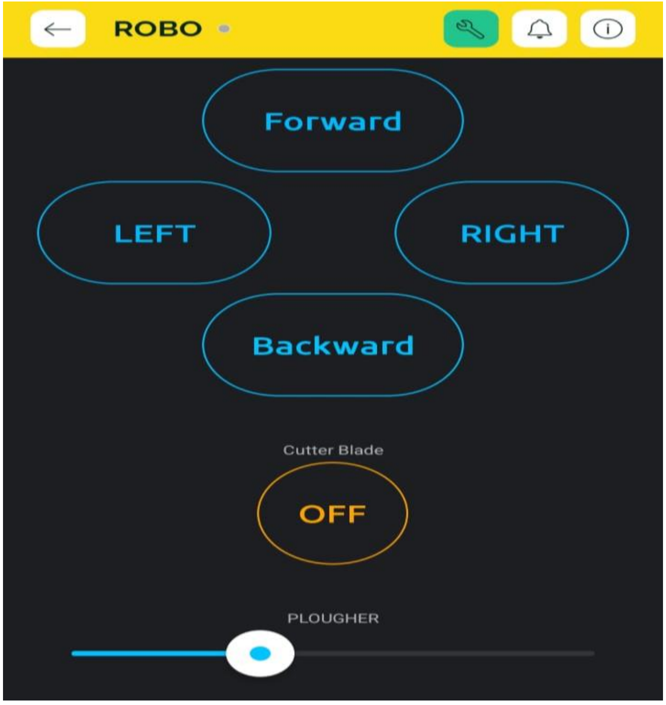
Snapshot 6.3: Solar Powered Grass Cutter

Snapshot 6.3 shows the Solar Powered Grass Cutter when clicked from the above. Dual-Axis Solar panel is mounted on the device so as to capture the solar energy to power the entire device



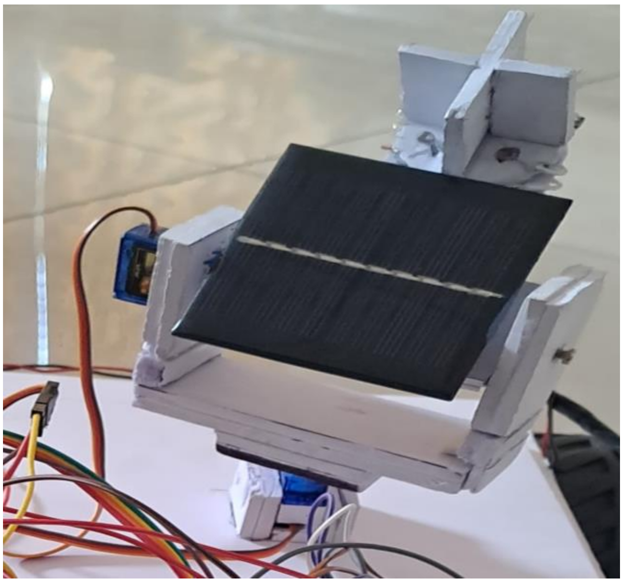
Snapshot 6.4: Battery Level Display

Snapshot 6.4 shows the Battery Level Display in the Blynk IoT app. This lets the user to know the current status of the battery.



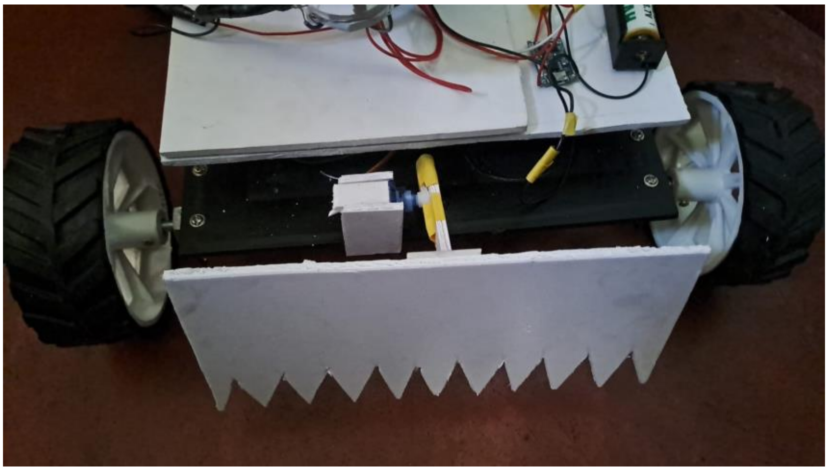
Snapshot 6.5: Mobile App Dashboard Screenshot

Snapshot 6.5 shows the User Interface designed for the user on the Blynk IoT app to control and monitor the Solar-Powered Grass Cutter.



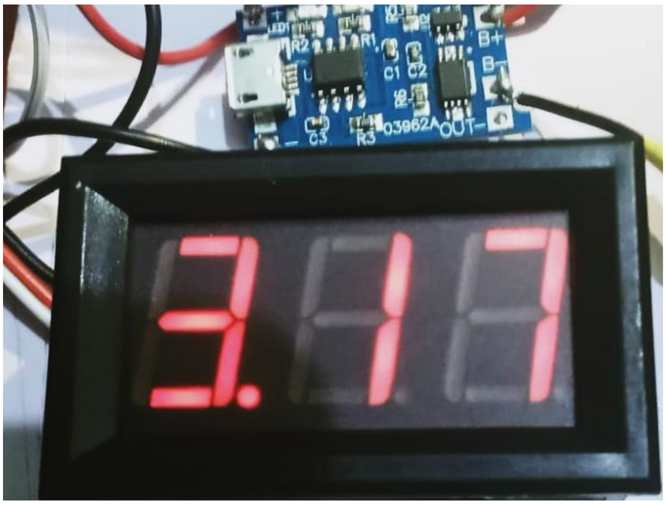
Snapshot 6.6: Dual Axis Solar Panel

Snapshot 6.6 shows the Dual-axis solar panel used for charging the batteries of the grasscutter.



Snapshot 6.7: Plougher

Snapshot 6.7 shows the plougher attached to the device for the initial preparation of the land for planting grass.



Snapshot 6.8: Voltage Reading from solar panel in voltmeter

Snapshot 6.8 shows the output voltage reading from solar panel measured in the digital voltmeter.

CONCLUSION AND FUTURE ENHANCEMENT

The development of this solar-powered automated grass cutter signifies a groundbreaking fusion of cutting-edge technologies aimed at elevating efficiency and sustainability in lawn maintenance practices. Initial phases of planning and research established clear project objectives and delved into existing technologies, providing crucial insights. The design phase emphasized the creation of a sturdy structure and efficient cutting mechanism, with a focus on durability and safety considerations. Through the integration of high-efficiency solar panels equipped with dual-axis tracking and a Wi-Fi module, the device is capable of harnessing renewable energy and facilitating remote control and monitoring via a dedicated mobile application. Utilizing an ESP32 microcontroller for seamless wireless control and an Arduino UNO for precise positioning of the solar panel ensures optimal energy capture. Rigorous testing and iterative improvements throughout the development process validate functionality and effectiveness in real-world scenarios, showcasing not only technical prowess but also a steadfast dedication to eco-friendly solutions.

This holistic approach not only showcases the potential of smart technology in reshaping traditional practices but also underscores a profound commitment to sustainability. Ultimately, this solar-powered grass cutter serves as a pioneering example of innovation in modern lawn care, offering a sustainable and efficient solution that aligns with contemporary environmental priorities.

To propel the Solar-Powered Grass Cutter into the next phase of innovation and effectiveness, several future enhancements can be explored:

- **Battery Optimization:** advanced battery technologies (e.g., lithium-Sulphur batteries) for increased energy storage capacity and longevity.
- **Extended Wi-Fi Range:** Enhancing the device's Wi-Fi connectivity by integrating a high-gain antenna or utilizing Wi-Fi range extenders to increase the operational range and reliability of remote control and monitoring capabilities.
- **Enhanced Sensor Suite:** Integrating advanced environmental sensors including soil moisture, temperature, and humidity sensors to provide real-time data on soil conditions that enables precise and efficient lawn maintenance strategies.

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APPENDIX