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SOLAR POWERED SMART GRASS CUTTER

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Abstract: Manual lawn maintenance is a repetitive, time-consuming, and often physically demanding task. This paper presents the design and development of a low-cost, semi-autonomous robotic grass cutter that can be remotely operated via a smartphone. The system is architected around the versatile ESP32 microcontroller, which provides both powerful processing capabilities and integrated Bluetooth connectivity. The robot's movement and the cutter's operation are controlled by DC motors managed through a motor driver module. A key feature of the system is its sustainable power management, incorporating a lithium-ion battery pack protected by a Battery Management System (BMS) and supplemented by a solar panel for on-the-go trickle charging. User control is achieved through a standard serial Bluetooth application on a smartphone, which sends commands to the ESP32 to navigate the mower and activate the cutting mechanism. This project demonstrates a practical, safe, and eco-friendlier alternative to traditional gasoline-powered lawn mowers.

Keyword: Robotic Lawn Mower, Solar Charging, Battery Management System (BMS).

I. INTRODUCTION

This paper presents a semi-autonomous, remotely operated grass cutter that prioritizes simplicity, user control, low cost, and sustainability. The system uses a smartphone interface to guide the machine, eliminating the need for complex autonomous navigation algorithms and sensors. The ESP32 microcontroller is the core, with built-in Bluetooth and Wi-Fi capabilities. The system is powered by a rechargeable lithium-ion battery, ensuring safety and longevity. A Battery Management System (BMS) is integrated for battery safety and longevity. A solar panel is also incorporated for supplemental charging. The design details the entire design, from electronic hardware integration to communication protocol, creating a robust prototype for a modern, user-centric lawn care solution.

II. OBJECTIVES

The objectives of the project:

- To design and develop of domestic purpose solar powered grass cutter Machine.
- Dev deploying of android application to control the machine effectively.
- To perform grass trimming operations at the user-specified location.
- We use solar panels to charge the batteries instead of using external power to do.
- To use solar power to limit the use of fossil fuels.

III. METHODOLOGY

This project is a solar-powered, completely automated grass-cutting machine that can function without requiring any human intervention. Both the vehicle motors and the lawn cutter motor in this arrangement are powered by 12 volt batteries. It is charged by a solar panel purpose of the battery, but it requires a charger to charge the battery during cloudy seasons. A four-channel relay that is interfaced to an ESP32 that controls all motor movements connects the vehicle motors and the lawn cutter motor.

A. BLOCK DIAGRAM

The solar panel is designed to receive high-intensity solar radiation and convert it into electrical energy, which is stored in a battery using a solar charger. The solar charger increases current while charging and disconnects the panel when fully charged. Motors are interfaced to the battery through a motor driver, and the Grass Cutter App controls the movement of the cutter. The app recognizes forward, backward, and right movements, and the blade is controlled by on and off mechanisms. A stop signal is used to avoid collisions with obstacles, and an ultrasonic sensor is connected to the cutter's head to prevent collisions.

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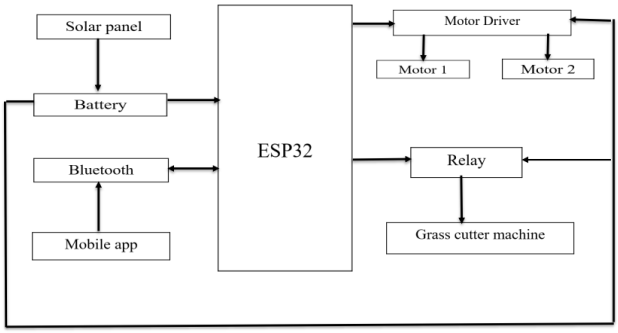

Figure 1 Block Diagram

B. Flowchart and Algorithm

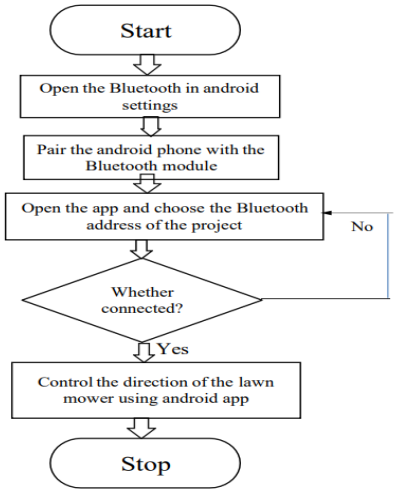

Figure 2 Flow Chart

This flowchart represents the process of controlling a lawn mower using an Android application through Bluetooth communication. The sequence begins with enabling Bluetooth in the Android phone's settings, after which the phone is paired with the Bluetooth module attached to the lawn mower. Once pairing is complete, the user opens the control application and selects the Bluetooth address of the project. At this stage, the system checks whether the connection has been successfully established. If the connection fails, the user is prompted to retry by selecting the Bluetooth address again. If the connection is successful, the Android application can then be used to control the direction of the lawn mower wirelessly. The process concludes once the operation is complete, ensuring a smooth interaction between the Android device and the lawn mower.

Algorithm is shown below

Step 1: Start.

Step 2: Initialize the ESP32.

Step 3: Open the Bluetooth Application of Grass Cutter

Step 4: Check the connection of Bluetooth

Step 5: If connected then move the machine in required direction

Step 6: Stop

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IV. HARDWARE DESCRIPTION

1. ESP32

The ESP32 Development board is a low-footprint, minimal system development board powered by the latest ESPWROOM-32 module. It includes basic support circuitry, an integrated antenna, RF balun, power amplifier, low noise amplifier filters, and power management module. The board supports three input and output modes: Digital, Analog, and internal sensors, making it safe, reliable, and scalable for various applications.

Figure 3 ESP 32

2. Driver circuit

An esp32 board provides control signals to a driver circuit, which in turn controls motors. It has output pins for the motors and input pins for the control unit and batteries. The module can run a DC motor with a peak current of up to 2A and a voltage between 5V and 35V. The Dc motor (wheels) is connected to the microcontroller by a motor driver. It regulates wheel motion in accordance with the microcontroller's instructions. Features: Pin Vcc , Pin Gnd, Pin A1, Pin A2, Pin B1, 6. Pin B2

Figure 4 Device driver

3. BO Motors

A BO (Battery Operated) Motor is a lightweight DC geared motor with good torque and rpm at lower voltages, suitable for battery operated lightweight robots. Driven by a single Li-Ion cell, these motors can run at approximately 100 rpm and operate at voltages ranging from 3.3 to 9v. They are commonly used in portable devices and vehicles due to their cordless operation.

Figure 5 BO Motors

4. BO Motor wheels

BO motor wheels are fixed to BO motors, allowing the wheels to move as the motor rotates. The wheels and motor are attached to a wood chassis, responsible for the entire system's movement. Plastic wheels are used in this system due to their lightweight nature. The wheel and shaft hole diameters are 70cm, 20mm, and 6mm respectively. A caster wheel rotates the vehicle in the direction of propulsion.

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Figure 6 BO Motor Wheels

5. Solar Pannels

A solar panel converts sunlight into electricity using photovoltaic (PV) cells, generating electrons that flow through a circuit to produce DC electricity. These panels are arranged in arrays or systems, and can be used for off-grid applications or grid-connected systems. Advantages include renewable energy, reduced greenhouse gas emissions, and lower electricity bills. Disadvantages include reliance on sunlight availability, maintenance, and high initial costs. Solar panels are widely used for residential, commercial, industrial, space, and transportation applications.

Figure 7 Solar Pannels

6. Blades

Mower blades are essential components of lawn mowers, typically made of study metals to withstand high-speed contact with various objects. Standard blades, also known as 2-in-1 blades, cut grass and discharge clippings. High-lift blades are straight and aerodynamic, creating a powerful lift. Basic lawn mowers often have plastic blades, which wear faster than metal blades, requiring more frequent blade replacements.

Figure 8 Blades

7. Jumper Wires

Typically used to link the parts of a breadboard or other prototype, a jumper wire is an electrical wire, or collection of them in a cable, having a connection or pin at each end. There is just one input and one output per jumper. The jumper can be used to connect microcontroller pins or to connect the pins of spare parts; the jumper input must be connected to one pin output, while the jumper output may be connected to many pin inputs.

Figure 9 Jumper wires

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8. Breadboard

A bread board is used to construct temporary circuits and is a solderless tool for temporary prototypes with electronics and test circuit designs. Designers find it helpful since it makes it simple to remove and replace components.

Figure 10 Breadboard

9. Lithium-ion battery

A lithium-ion battery, often known as a Li-ion battery, is a kind of rechargeable battery that stores energy by reducing lithium ions reversibly. Graphite, a carbon-based material, is commonly used as the anode in a traditional lithium-ion battery.Usually, a lithium salt in an organic solvent serves as the electrolyte, and a metal oxide serves as the cathode.

Figure 11 Li-ion battery

V. SOFTWARE REQUIREMENTS

1. Embedded C language

Embedded C is a programming language used for developing embedded systems, which are computer systems designed to perform specific tasks integrated into larger systems. In a smart solar grass cutter project, the embedded C program controls the device's operation, including blade speed, battery level monitoring, and communication with integrated sensors. A strong understanding of software and hardware components and project requirements is crucial for programming an embedded C system effectively. The embedded C program is crucial for the machine's efficient operation and desired results.

2. Arduino IDE

The Arduino IDE is a software tool that simplifies programming Arduino microcontrollers, particularly for smart solar grass cutter machines. It allows for easy code upload and control of the machine's electronic components, including solar panels, motors, and cutting blade. This essential tool enables the creation of customized software tailored to specific needs.

VI. RESULTS AND DISCUSSION

With a completely charged battery, the run time is forty-five minutes.The area of cut (battery time) is dependent on lawn conditions, grass density, moisture content, grass length, and grass height; the maximum cutting height is 1" inches.In manual mode, We may run a fully automated solar lawn cutter in this mode by using the manual controls provided in the Control application. We can carry out commands for left, right, forward, backward, and stop motions in this mode.

Energy is a major factor in many people's lives these days. When the battery is depleted, the solar panel is utilised to recharge it. With the aid of an Android phone, we can operate a lawn cutter that allows us to cut grass in any desired shape and with minimal human labour. The Arduino IDE program was utilised to conduct the simulation. Second, the project has been successfully designed and tested thanks to the use of very advanced integrated circuits (ICs) and expanding technologies.

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Figure 12 Project model

Figure 13 Serial Bluetooth terminal application

VI. APPLICATIONS

Someof applications are:

1. Home gardens and lawns: The system can be used in residential gardens and lawns to maintain grass neatly without manual effort. It ensures uniform cutting and saves time for homeowners.
2. College campuses and institutional areas: Large campuses require regular maintenance of green spaces. The grass cutter can be employed to keep lawns, gardens, and pathways clean, thereby improving the campus environment.
3. Botanical gardens and landscaped areas: In places where ornamental plants and lawns are maintained for educational, research, or tourism purposes, this system can provide consistent and eco-friendly maintenance.
4. Agricultural fields: The grass cutter can be used for automatic cutting of grass and weeds in agricultural lands, reducing the need for manual labor and lowering dependency on chemical weed control methods.
5. Small farms: Farmers with small to medium-sized fields can use this machine for weed and grass removal, reducing time and physical effort.

VII. ADVANTAGES

Some of the applications are:

1. Portable and Easy to Use: The machine is compact, lightweight, and easy to move from one place to another. Its simple operating principle makes it user-friendly, even for unskilled people.
2. Eco-friendly and Quiet Operation: Powered entirely by solar energy, it eliminates fuel usage, reduces air pollution, and produces much less noise compared to conventional grass cutters.
3. Economical and Self-sufficient: With no fuel expenses and low operational cost, it is economical. The built-in solar charging system makes it self-sustaining without dependency on external power.
4. Efficient and Flexible Performance: The cutter is faster and more efficient than traditional machines, and since it stores energy in the battery, it can work both during the day and at night if properly charged.

VIII. DISADVANTAGES

Some of the disadvantages are:

1. Dependence on Solar Energy: The system runs entirely on solar power, which, although renewable and freely available, is dependent on sunlight. Its performance may reduce on cloudy days or in regions with limited sunlight.
2. Time-Consuming Operation: Compared to large fuel-powered grass cutters, this machine requires more time to cover bigger areas, which can be a drawback when used for large fields or commercial applications.
3. Manual Supervision Required: The cutter is not fully automated and still requires manual guidance or operation, which may increase physical effort for the user during extended use.

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4. Limited Usability in Rainy Season: Since the system relies on solar charging, it becomes difficult to operate efficiently during the rainy season or in wet conditions, as solar charging is reduced and wet grass may also affect performance.

IX. FUTURE SCOPE

Some of the future Scope are:

1. Adjustable Cutting Mechanism: In the future, the machine can be designed with a smart height-adjustable blade system that automatically adapts the grass cutting height based on the rate of grass growth, ensuring uniform and efficient lawn maintenance.
2. Automation with Self-Navigation: By integrating sensors and navigation systems, the grass cutter can be made fully automated with self-driving capabilities. This would allow it to operate without human supervision, covering lawns and fields systematically.
3. Multipurpose Smart Monitoring:The system can be upgraded into a multipurpose machine capable of monitoring additional environmental parameters such as temperature, air quality, and soil moisture. This would make it useful not only for cutting grass but also for smart farming and environmental management.
4. Cost-Effective and Sustainable Solution: With rising fuel costs and increasing labor shortages, a fully automated solar-powered grass cutter will become highly beneficial. Its eco-friendly, self-sustaining design will provide an economical and effective alternative to conventional grass cutting methods.

X. CONCLUSION

These days, every equipment is made to reduce or eliminate the production of polluting gases, which are one of the main drivers of climate change. Because it runs on free solar energy, this clever solar-powered grass cutter doesn't require fuel.Because of its little weight, this grass cutter is convenient to transport from one location to another. The diesel or gasoline-powered grass cutter may be replaced by this intelligent solar-powered model. A human is only required to enter data via a mobile application (Serial Bluetooth terminal); after that, they are not required. This smart solar lawn cutter prototype was successfully tested and found to operate effectively. Because of the solar charge controller, the battery is constantly charged while operating.

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APPENDIX – SOURCE CODE

```
#include <BluetoothSerial.h>
#include <NewPing.h>              // Include NewPing library

#define RELAY 26                  // Motor and Relay Pins
#define motorpin1 18
#define motorpin2 5
#define motorpin3 2
#define motorpin4 4

#define TRIGGER_PIN 33            // Ultrasonic Sensor Pins
```

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```
#define ECHO_PIN 32
#define MAX_DISTANCE 200            // Maximum distance to measure in cm

BluetoothSerial SerialBT;
  NewPing sonar(TRIGGER_PIN, ECHO_PIN, MAX_DISTANCE); // NewPing instance
  void setup() {
pinMode(motorpin1, OUTPUT);          // Motor Pins Setup

   pinMode(motorpin2, OUTPUT); pinMode(motorpin3, OUTPUT); pinMode(motorpin4, OUTPUT);
  pinMode(RELAY, OUTPUT); digitalWrite(RELAY, HIGH);          // Relay Pin Setup
  Serial.begin(115200);                                       // Serial and Bluetooth Initialization
            SerialBT.begin("Grass cutter new");               // Bluetooth name
  Serial.println("Bluetooth is ready to pair.");
  }
  void loop() {
  if (SerialBT.available()) {
   String command = SerialBT.readStringUntil('\n');              // Read command from
  Bluetooth app
   command.trim();                          // Remove any extra whitespace or newline characters
   if (command == "forward") {
   moveForward();
   } else if (command == "backward") {
   moveBackward();
   } else if (command == "left") {
   moveLeft();
   } else if (command == "right") {
   moveRight();
  } else if (command == "stop") {
   stopMovement();
   } else if (command == "cut") {
   digitalWrite(RELAY, LOW);                                    // Activate relay
   Serial.println("Relay ON");
   } else if (command == "stop cut") {
   digitalWrite(RELAY, HIGH);                                   // Deactivate relay
   Serial.println("Relay OFF");
   } else {
   Serial.println("Unknown command: " + command); }
   //checkObstacleAndAvoid(); // Continuously check for obstacles
  // Check for obstacles and change direction to avoid collision //void checkObstacleAndAvoid() {
  // delay(50);                                  // Short delay to prevent excessive polling
  // unsigned int distance = sonar.ping_cm();      // Get distance in cm
  // if (distance > 0 && distance <= 10) {        // If object is detected within 10 cm
  // Serial.println("Obstacle detected! Changing direction.");
  // moveLeft();                          // Turn left to avoid collision
  // delay(1000);                       // Delay to complete the turn
  // stopMovement();   //}       // Movement Functions
  void moveForward() {
  digitalWrite(motorpin1, HIGH); digitalWrite(motorpin2, LOW); digitalWrite(motorpin3, HIGH);
   digitalWrite(motorpin4, LOW); Serial.println("Moving Forward");
  }
  void moveBackward() {
   digitalWrite(motorpin1, LOW);  digitalWrite(motorpin2, HIGH); digitalWrite(motorpin3, LOW);
   digitalWrite(motorpin4, HIGH); Serial.println("Moving Backward");
  }
  void moveLeft() {
   digitalWrite(motorpin1, HIGH); digitalWrite(motorpin2, LOW); digitalWrite(motorpin3, LOW);
   digitalWrite(motorpin4, HIGH); Serial.println("Turning Left");
  }
  void moveRight() {
   digitalWrite(motorpin1, LOW); digitalWrite(motorpin2, HIGH); digitalWrite(motorpin3, HIGH);
   digitalWrite(motorpin4, LOW); Serial.println("Turning Right");
  }
  void stopMovement() {
   digitalWrite(motorpin1, LOW); digitalWrite(motorpin2, LOW); digitalWrite(motorpin3, LOW);
   digitalWrite(motorpin4, LOW); Serial.println("Stopping");
  }
```