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Design and Implementation of Sustainable Turf Management Robot

1st ADHILABANU A
UG Scholar
Electronics and Communication Engineering
Paavai Engineering College
Namakkal, India
abdulsamath71@gmail.com

2nd MOHANAPRIYA R
Associate Professor
Electronics and Communication Engineering
Paavai Engineering College
Namakkal, India
mprmpriya@gmail.com

3rd JANANI M
UG Scholar
Electronics and Communication Engineering
Paavai Engineering College
Namakkal, India
jananim266@gmail.com

4th MONIKA G
UG Scholar
Electronics and Communication Engineering
Paavai Engineering College
Namakkal, India
monikagrbs@gmail.com

Abstract

The Robotic Solar Grass Cutter is an advanced lawn maintenance solution that harnesses solar power for eco-friendly, cost-effective operation. Equipped with ultrasonic sensor and Arduino IDE, it autonomously navigates lawns, avoiding obstacles and ensuring precise grass cutting. This innovative device operates quietly, requires minimal maintenance, and significantly reduces its environmental impact by eliminating the need for gas or electricity from non-renewable sources. Its user-friendly interface allows homeowners and landscapers to customize settings and schedules easily. Our Robotic Solar Grass Cutter offers a sustainable and efficient approach to lawn care, combining renewable energy with Bluetooth module for a well-manicured, eco-conscious yard.

Keywords: Arduino IDE, Bluetooth Module, Solar power, Ultrasonic sensor, Grass cutter

Introduction

The Robotic Solar Grass Cutter represents a cutting-edge solution for modern lawn maintenance. This innovative device combines the power of robotics and solar energy to efficiently trim and maintain grassy areas. Powered by clean and renewable solar energy, it operates silently and without emitting harmful emissions, making it an eco-friendly choice for landscaping. Equipped with advanced sensors and AI technology, the robotic grass cutter navigates the terrain autonomously, avoiding obstacles and ensuring precise and even grass cutting. Its efficient design and precision cutting blades make it ideal for both residential lawns and larger commercial spaces. One of the key benefits of the Robotic Solar Grass Cutter is its low maintenance requirements. It operates with minimal human intervention, reducing the need for manual labor and fuel-powered equipment. Additionally, its solar panels harness energy from the sun, reducing operational costs and environmental impact.

This robotic innovation not only saves time and effort but also contributes to a greener and more sustainable future. With its ability to maintain lawns efficiently and eco-consciously, the Robotic Solar Grass Cutter is poised to revolutionize the way we care for our outdoor spaces, offering a glimpse into the future of landscaping technology.

Literature Review

Today people are too busy from day to day to cut the grasses at the house lawn. In order to be more convenience on doing the jobs with fast cut without hassle during cutting the grasses, a device is created which make the process easier. The machine gives the advantages such as easy to handle environmentally, fast without standing under the sunlight [17]. The solar panel is used for charging the battery when it gets discharged. Here the grass cutter is controlled with the help of Android phone to any shape without much human efforts. For the simulation, the proteus software is used where the obstacle gets near to Ultrasonic sensors and distance between the obstacle and robot is displayed on the LCD [1]. DC motors are connected to the wheel of the device through the motor driver circuitry. The working prototype designed for the Grasscutter system that is controlled through Android mobile through the Blynk application [6]. The torque of the DC motor interfaced to control the blade of Grasscutter to shear the grass [10]. Customized Harvard architecture with 8 bits Reduced Instruction Set Computer processor (RISC)

core Arduino UNO single-chip microcontroller belongs to Atmel within mega AVR family. The recommended input voltage varies from 7V to 12V, where the operating voltage is 5V. So, the battery leads are connected to the VIN and GND pin of the controller as power connectors to the controller. Arduino UNO consists of a total of 20 pins, out of which 14 pins are digital pins and 6 pins are analog pins. These pins help in executing/operating functions like digital write, digital read, pin mode, TTL (Transistor-Transistor Logic) serial communication, interrupts, SPI (Serial Peripheral Interface) communication, TWI (Two-Wire Interface) communication and analog write.

IoT-based solar grass cutting robots are a promising solution for lawn maintenance, offering a range of benefits, including reduced carbon emissions, lower maintenance costs. IoT-based solar grass cutting robot is a sustainable and efficient solution for lawn maintenance, and its potential for further development makes it an exciting prospect for the future of gardening and landscaping [2]. The project aims to use renewable energy sources like solar electricity and to operate a cutter equipped with various accessories and to cut and gather lawn grass. The DC motor, powered by a battery, where the charge is kept via a solar panel, has a spiral shaped grass cutting blade. The solar panel is attached to the structure and charges if the system does not run, transferring charges to the battery through the circuit. During the day and night, the solar grass cutter uses both [3].

The Solar grass cutter is a grass-cutting robot that is powered by the sun. The system uses 12V batteries to power the car's moving engines and a lawn mower. The lawn mowers and cars are controlled by the Mobile Phone and Arduino system [5].

Lawn mower based on axis of rotation blades we have reel lawn mower and rotary lawn mower [6]. Initially, blades were utilized to cut the lawn and then manual lawn mowers introduced but engine is not used in manual mowers, and they developed a solar grass cutter robot which works by utilizing solar energy. An autonomous remote control solar power lawn mower robot that can be controlled through mobile phone [12].

A workable smart solar grass cutter prototype focusing on the renewable energy as the primary sources of energy and fabricated with high working efficiency. Here Smart Solar Grass Cutter reduces the air pollution, and it is a user-friendly device [7]. The advancement in grass cutter technology has been significant, whether it is in terms of using renewable solar energy or in making the grass cutter safety equipped. So, in new designs there should be fire detection and extinguishing mechanism so that an overall safer device can be provided to the public especially in areas of hot weather, drought conditions as when the weather is dry the vegetation is more at risk of catching fire even by a spark [9].

The components chosen in [8] are based on the design requirement and considering few of the other parameters to meet all the constraints. Based on the revived prototype model of the hardware and software system along with the ultrasonic sensor were demonstrated and required output was obtained. The cutter is designed in such a way that it can cut the grass efficiently and height from the ground level can be adjusted from 2mm to 70mm.

Proposed Methodology

The Robotic Solar Grass Cutter represents a cutting-edge solution for modern lawn maintenance. This innovative device combines the power of robotics and solar energy to efficiently trim and maintain grassy areas. Powered by clean and renewable solar energy, it operates silently and without emitting harmful emissions, making it an eco-friendly choice for landscaping. Equipped with advanced sensors and AI technology, the robotic grass cutter navigates the terrain autonomously, avoiding obstacles and ensuring precise and even grass cutting. Its efficient design and precision cutting blades make it ideal for both residential lawns and larger commercial spaces. One of the key benefits of the Robotic Solar Grass Cutter is its low maintenance requirements. It operates with minimal human intervention, reducing the need for manual labor and fuel-powered equipment. Additionally, its solar panels harness energy from the sun, reducing operational costs and environmental impact. This robotic innovation not only saves time and effort but also contributes to a greener and more sustainable future. With its ability to maintain lawns efficiently and eco-consciously, the Robotic Solar Grass Cutter is poised to revolutionize the way we care for our outdoor spaces, offering a glimpse into the future of landscaping technology.

Hardware Components used in this project is Arduino UNO Acts as the brain of the system, handling control and communication. Bluetooth Module HC-06 Provides wireless communication with the mobile app. Motor Control Hardware includes motor drivers to control the grass cutter's movement. Safety Sensors like ultrasonic sensors or bump sensors for obstacle detection, mobile device (Android or iOS), user's smartphone or tablet, which runs the mobile.

Software Components used in this project are Arduino UNO Software. The software running on the Arduino UNO, responsible for motor control and Bluetooth communication. Developed in a language like Python. Mobile App for Android that allows users to control the grass cutter via Bluetooth. The app should have features like start/stop, emergency stop, and possibly obstacle detection.

System Functionalites are the mobile app establishes a Bluetooth connection with the Arduino UNO. Users can control the grass cutter using the app, issuing commands to start, stop, or steer. Safety mechanisms are in place to prevent accidents, like stopping the cutter if an obstacle is detected. The app can provide real-time feedback on the cutter's status, battery level, and error alerts.

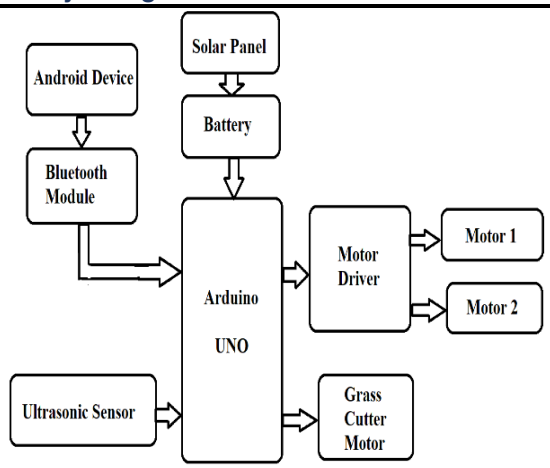

Figure 1: Schematic diagram of the Robotic Solar Grass Cutter

Arduino UNO

Arduino/Genuino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button.It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards.

Solar Panel

A solar panel is a packaged interconnected assembly of solar cells, also known as photovoltaic cells. The solar panel is used as a component in a larger photovoltaic system to offer electricity for commercial and residential applications. Because a single solar panel can only produce a limited amount of power, many installations contain several panels. This is known as a photovoltaic array.

L298N Motor Driver

The L298N Dual H-Bridge motor driver is a low-cost motor driver board in the market that can drive 4 motors it uses the popular L298N dual H-Bridge Motor Driver chip & is also powerful enough to drive motors from 5-35 volts at 2 amps per channel. This Board provides a handy 5V Regulator that can be used to power another circuit such as ESP8266, Arduino or another Micro-controller.

Relay

A relay is an electrically operated switch. Current flowing through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw (changeover) switches. Relays allow one circuit to switch a second circuit which can be completely separate from the first. For example, a low voltage battery circuit can use a relay to switch a 230V AC mains circuit.

Motor

A gear motor is usually a simple DC electric motor with a gear mechanism attached to it. DC Motor – 1000RPM – 12Volts It will be involved across all robots and robotic packages in varying sorts. With such motor, that has a voltage around 5 and 35V DC, you can use the most prominent L298N H-bridge device with inbuilt voltage regulator motor driving force, or one can choose the most appropriate motor diver module from the expansive range available in our Motor divers' category, depending on your particular needs.

Ultrasonic Sensor

HC-SR04 ultrasonic range sensors are used, the principle behind this sensor is that it uses sonar to determine the distance to an object and it offers the excellent non-contact range detection with high accuracy and stable readings. The sensor is connected to the microcontroller. Generally, ultrasonic sensor ranging distance is from 4cm to 400cm, but in our project programming is done like that, if any object is at distance of 20cm it stops cutter motor and start taking 180º turn and start cutting grass in another lane. Ultrasonic sensor is fitted in front of the solar grass cutter.

Ultrasonic sensor is selected, because of its suitability for outdoor application, since intensity of the sunlight does not affect the sensor, it sends the sound waves unlike the light waves in case of infrared (IR) sensor [8].

Rechargeable Battery

A 6v batteries will commonly hold enough price for 45-60 minutes of continuous use, whilst 12v batteries can maintain enough for two-four hours depending at the power necessities of the mounted motor. 24v batteries range, again relying on the energy usage of the motor, however commonly last between 2-4 hours. The capacity of the battery is given for a particular discharge contemporary. With a higher discharge modern, you will get less electricity from the battery. With a decrease discharge modern, you will get greater power from the battery.

Bluetooth module

To connect the smartphone to the Bluetooth module and the Arduino is to activate the Bluetooth and the smartphone and find the HC-05 Bluetooth module.

Then, pair the devices and the default password of the HC-05 module is given as 1234. After we have paired the devices, we need an application for controlling the Arduino. There are many applications in the Play Store for this purpose which will work with the Arduino code that we wrote. However, we have made our own custom application for this tutorial using the MIT App Inventor online application. This is a great and easy to use application for building Android app.

Arduino Software (IDE)

Arduino IDE is an open-source software designed for coding and compiling code into Arduino Modules. As the official Arduino software, it simplifies code compilation, making it accessible even to those without technical expertise. Compatible with MAC, Windows, and Linux, the IDE operates on the Java Platform, offering built-in functions crucial for debugging, editing, and code compilation. Various Arduino modules, such as Uno, Mega, and Leonardo, are available. The IDE's primary components include the Editor for code creation and the Compiler for code compilation and upload to the Arduino Module. The generated Hex File from the main code, known as a sketch, is transferred and uploaded to the board's controller.

Conclusion

In our paper, the grass cutter is controlled with the help of Android phone and Bluetooth module so that the grass can be trimmed and cut in any shape without much human efforts. The solar panel is used for charging the battery when it gets discharged. Here, for simulation the proteus software is used to show the results of desired operations. Augmented Reality and image processing applications will be the future scope of our work.

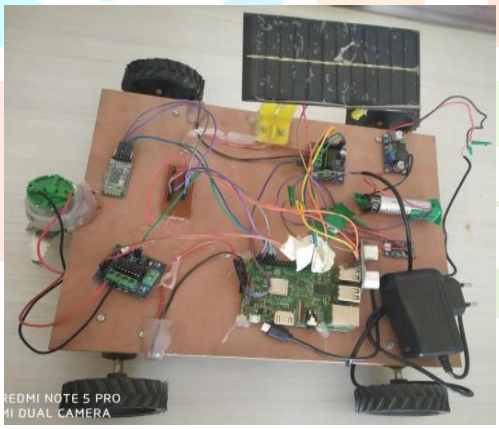

Figure 2: Prototype model of our Robot grass cutter

The system utilized the IoT technology to create a prototype grasscutter robot that can be controlled remotely using a solar energy source. The robot can operate by sending seven signals to the Bluetooth module of Blynk app, which it can use to cut the grass. The control mechanism for the prototype includes the forward, backward, right, left, and stop movements. The energy generated by the solar panels helps the grasscutter operate economically.

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