Automatic Grass Cutting Robot

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Abstract—

This project presents the design and implementation of an Automatic Robot that has the ability to cut grass at a particular level set by the maker, and which also has the feature of obstacle detection.

The system is designed to operate autonomously, reducing the need for manual labor in lawn maintenance. It utilizes a microcontroller to coordinate motor functions and sensor inputs, enabling it to navigate the lawn while simultaneously detecting and avoiding obstructions.

Additional battery or power sources were required to ensure safe and smooth running of the model. An Arduino microcontroller mounted with an Adafruit shield serves as the main control unit that powers the sensors and controls the motor movements, hence demonstrating how embedded systems and sensor integration can enhance functionality and safety in robotic applications.

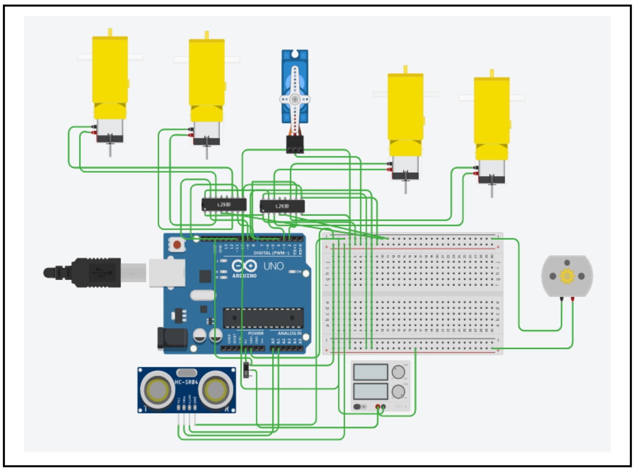
I. Introduction

With the increasing demand for automation in day-to-day activities, the development of autonomous systems for routine tasks has gained significant attention. Lawn maintenance is one such task that requires regular effort, time, and physical labor. Conventional grass cutting involves manual operation of lawn mowers, which can be tiring and inefficient, especially for larger areas. This Automatic grass cutting robot eliminates this issue and proves as a suitable and automated solution.

The system employs an **HC-SR04 ultrasonic sensor** to calculate the distance of nearby objects. The primary aim of this is to reduce human involvement, so servos and dc motors ensure that the system does not hit an obstacle, instead moves away from it according to a suitable direction.

Unlike traditional lawn maintenance systems, which rely on manually driven and often costly components, this project uses simple, readily available hardware to understand different motor functions integrated with sensors in the small scale. This not only keeps the system cost-effective but also makes it an excellent platform for learning about embedded systems and sensor integration.

This project not only shows the potential of embedded systems and automation in simplifying domestic tasks but also opens avenues for more advanced applications such as solar-powered operation, smart scheduling, and integration with mobile apps or home automation systems. Overall, the Automatic Grass Cutting Robot is a step toward smart, efficient, and user-friendly lawn maintenance solutions.



II. Objectives

A. Development of an object detection mechanism

Utilizing the ultrasonic sensor to measure the distance of objects within a set range of 40 cm and sending the signals to the Arduino for further instructions.

B. Direction checking mechanism

Once an object is detected, the servo moves in two angles, such that the mounted sensor seems to be looking at both the right and left directions at 50°.

In each direction, the sensor calculates distances and compares them with each other to determine the direction the system should move.

C. Real-time mobility

Once the direction is chosen, the dc motors move accordingly (given by the code) to avoid the obstacle, turn the robot in that particular direction and move front as normal. This ensures that the robot detects an object when placed suddenly in its line of motion.

D. Mowing ability of the robot

A fan/ blade is fixed to the BLDC motor, which is powered by an external 11.1V battery. When the system is turned on, the BLDC starts rotating at high speeds, hence ensuring that the grass is cut smoothly in a constant level.

III. SIGNIFICANCE OF PROJECT

The development of the Automatic Grass Cutting Robot holds practical and technological significance in the modern era, where automation is becoming essential in improving efficiency, safety, and convenience. This project addresses a common domestic challenge—lawn maintenance—and offers an innovative solution that minimizes human effort while increasing precision and effectiveness.

A. Labor Reduction

Manual grass cutting can be physically demanding and time-consuming. The robot automates this task, allowing users to save time and reduce physical effort, which is especially useful for elderly or physically challenged individuals.

B. Consistency and Precision

Unlike manual methods, which may vary in performance, the robot ensures uniform grass cutting at a predefined height, resulting in a consistently neat and well-maintained lawn.

C. Safety Enhancement

Traditional lawn mowers can pose risks due to human error or improper handling. This robot incorporates obstacle detection, reducing the chance of collisions and accidents, and operates autonomously under safe conditions.

D. Potential in Real-World Applications

- **Agriculture, Horticulture and residential lawns**: Homeowners can use this robot to automate regular grass cutting, reducing their need for manual labor while ensuring a consistently maintained lawn. The robot can be adapted to work in farms or nurseries to manage weeds and unwanted grass growth, promoting healthier crops and plant environments.
- **Smart City Integration and IOT:** These robots can be integrated into smart city frameworks, where they operate based on schedules or environmental conditions, coordinate via IoT, and report maintenance statistics in real time.
- **Robotics and landscaping service**: As automation trends rise, companies offering landscaping services can adopt this robot as part of their modern toolset, increasing efficiency while reducing manpower needs.

E. Energy Efficiency and Eco-Friendliness

Since the robot is powered by a rechargeable battery, it contributes to reducing fossil fuel usage and noise pollution typically associated with gas-powered lawn mowers.

F. Scalability and Future Integration

The project serves as a foundation for future developments such as solar-powered operation, GPS-based navigation, IoT integration, and smart scheduling—paving the way for fully intelligent lawn care systems.

IV. METHODOLOGY

The project involved careful design and implementation involving software and hardware integration. The process involved hardware setup, circuit design, software implementation, and real-time data, with each phase contributing to the final working system.

A. System Design and Component Selection

*1) **HC-SR04 Ultrasonic Sensor**: This sensor was selected for its ability to measure distances based on the time it takes for sound waves to travel to an object and return. This sensor is cost-effective, widely available, and simple to interface with the Arduino microcontroller.*

*2) **BLDC motor:** Known for its high speeds, it poses as the perfect rotor part to which a blade can be connected to create the cutting/ mowing mechanism.*

*3) **Arduino Uno**: The Arduino Uno was chosen due to its simplicity and suitability for small-scale projects. It was responsible for controlling both the sensors, the servo motor, and dc motors, while being powered by an external 11.1V battery.*

*4) **Adafruit Arduino Shield**: An Arduino Shield was needed to prevent overpowering and ensuring the stability of the system when connected to high voltage battery packs and multiple components under the same roof.*

*5) **Servo Motor**: A standard servo motor was fixed in the front of the robot, mounted with the HC-SR04 servo motor, hence helping the system to calculate distances in either directions during obstacle detection.*

*6) **External battery packs**: totally, two battery packs are used in this project for safe and smooth operation. One is the 11.1V LIPO battery, which powers up the mowing mechanism and the arduino which not connected* *to a laptop. The other source are 4 AA batteries connected in series to provide 6V to the servo motors seperately.*

B. Hardware Setup and Wiring

Once the components were chosen, the next step involved assembling the hardware. The connections were made as follows:

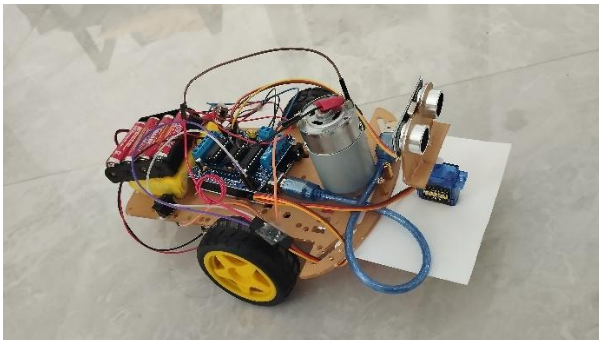
- **Ultrasonic Sensor (HC-SR04)**: The sensor's VCC and GND pins were connected to the 5V and GND pins of the Arduino, respectively. The TRIG and ECHO pins were wired to **Analog pins A0 and A1** respectively on the Arduino Shield to trigger and receive the reflected ultrasonic signals.

- **Servo Motor**: The servo motor's control pin was connected to **the signal pin** on the shield, to control it via the Adafruit module. The servo was used to sweep the ultrasonic sensor across a predefined arc to simulate obstacle detection.

- the **11.1V** LIPO battery was connected to the BLDC motor via a switch at the positive side, and also to the Arduino Shield's +M and GND ports to ensure smooth movement of the dc motors.

  The AA battery pack was connected to the Servo motor's positive and GND pins, hence powering it up.

- DC Motors: totally 2 DC motors were used in this project, and each connected to M3 and M4 ports on the shield. M1, M2, M3 and M4 are the motor ports that connect the dc motors directly to the Arduino for control.



C. Software Development

The software was developed in the Arduino IDE to control and process data from the sensors, calculate the distance and speed, and display the results on the LCD. The program follows these steps:

- **Distance Measurement**: The HC-SR04 sensor was programmed to send a pulse to the TRIG pin, causing the sensor to emit ultrasonic waves. The time taken for the echo to return was measured, and the distance was calculated using the formula:

$$\text{Distance} = \frac{\text{Time} \times \text{Speed of Sound}}{2}$$

- **Servo Motor Control**: The servo motor was programmed to rotate the ultrasonic sensor across two directions. This rotation simulated the scanning behaviour, allowing the sensor to detect objects in its path. The Arduino controlled the servo using PWM (Pulse Width Modulation) to move the sensor in the right and left direction to calculate and compare the distance at a certain angle and time.

- **BLDC Motor control**: the BLDC motor used for the mowing blades were set at a constant speed using the ESC and servo tester. This ensures that the blades do not run in enormous speeds and cause damage to other underlying components in the project.

D. Real-Time Data features

The final system involved real-time detection and obstacle-avoiding

As the system ran, the servo motor moved the ultrasonic sensor, scanning the environment and measuring the distance to objects. Depending on this distance it was determined, which direction the robot should move.

E. Testing and Calibration

After the system was assembled and programmed, the next step involved testing and calibration:

- The system was tested by placing objects at various distances to ensure the ultrasonic sensor accurately measured distance.
- The servo was tested for movement to the left and right depending on the distance measured by sensor.
- Calibration was performed to adjust the servo motor such that it moves only when an object is detected, and is fixed at a particular starting angle when no object is detected and robot is meant to move forward.
- Careful testing was required to check the compatibility of each component with the battery packs.
- Finally, a final test run to ensure the mower, the sensor and the servo were moving simultaneously, with perfect amount of power supplied to each and according to commands given through the Arduino.

V. RESULTS

A. *Distance Measurement*

The Grass cutting robot provided as a safe and reliable tool, with object detection within a range of 40 cm.

B. *Autonomous Operation*

The robot was able to move independently without human intervention, navigating over grassy surfaces with stability and control.

C. *Obstacle avoidance and Mobility*

Ultrasonic sensors accurately detected obstacles such as stones, walls, and plant pots within the sensing range. Upon detection, the robot successfully stopped, recalculated its path, and continued movement in a different direction.

D. *Safety, Reliability, and stability of the system*:

The chassis and mechanical structure remained stable during operation, confirming the durability of the robot's physical design. The system operated safely without damaging surroundings or encountering mechanical failure during testing. Emergency stop logic and safe motor control ensured reliable performance.

CONCLUSION AND SCOPE OF THE PROJECT

[1] Successfully Made the Tinker cad and EasyEDA circuit of an Automatic Grass Cutting Robot and used them to create the Gerber file.

[2] With the functions and examples given in the demo videos in the L&T LMS, created two codes – one for the Tinker cad simulation, and one for the hardware model (Uploaded in GitHub).

[3] Made a hardware model of the Grass Cutting robot, following certain safety measures (mentioned in demo).

[4] Industrial and High-power appliances can be used to make it suitable for commercial landscaping and farming on dry land.

[5] Integrating the grass-cutting application with a rainsensing facility will allow the robot to sense high moisture content in the soil before moving further, hence preventing damage.

[6] IOT modules can be integrated by sending real-time info on the sensor readings and moisture content of the soil to an online platform.

[7] Connecting the system to an application or webpage to control the robot via start, stop and directional buttons helps a user to control the robot manually in case of any visible errors or damage.