Mobile Controlled Solar Lawn Trimmer

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Abstract - This paper presents the development of an IoT-enabled, solar-powered grass cutter designed for autonomous operation in lawn maintenance tasks. The system is powered by solar energy for eco-friendly operation and utilizes an Arduino Uno as the central controller. Key components include a solar panel with a charge controller, battery, motor drivers, and a servo-mounted ultrasonic sensor for obstacle detection. The robot is programmed to follow a predefined square path to ensure systematic coverage of the area. It supports dual operation modes such as Bluetooth and Ultrasonic that can be toggled through a mobile application. The integration of IoT enables real-time monitoring and control, reducing the need for manual supervision. Field tests confirm the system's ability to navigate accurately, avoid obstacles, and operate efficiently under varying light conditions, demonstrating its suitability for maintaining lawns in public parks, institutions, and other open spaces.

***Key Words*:** solar-powered, Arduino Uno, IoT, grass cutter, square path navigation, automation.

1. INTRODUCTION

In recent years, the need for sustainable and efficient gardening solutions has grown, prompting the development of eco-friendly and automated systems. One such innovation is the mobile-controlled solar-powered lawn trimmer, which combines modern technology with environmental consciousness. This project aims to design and implement a solar-powered lawn trimmer that operates through Bluetooth control, offering users a convenient and energy-efficient way to maintain their lawns.

The system integrates a solar panel to harness solar energy, ensuring uninterrupted operation without relying on external power sources. A Bluetooth module allows for wireless control, enabling the user to direct the trimmer's movements from a mobile device. The trimmer is equipped with an ultrasonic sensor to detect obstacles, ensuring precise trimming while avoiding potential damage to plants or structures.

This project not only contributes to the automation of lawn care but also promotes the use of renewable energy sources, making it a sustainable solution for modern gardening needs. Through this paper, we aim to present the design, development, and potential applications of the mobile-controlled solar lawn trimmer, exploring its functionality, efficiency, and environmental benefits.

2. METHODOLOGY

The methodology for developing the mobile-controlled solar lawn trimmer begins with the design of the solar power system. A solar panel is selected according to the power requirements of the trimmer and its components, ensuring sufficient energy collection and efficient charging of a rechargeable battery. A power management circuit is integrated to regulate voltage and ensure consistent energy distribution to the system. The next step focuses on integrating a Bluetooth module with a microcontroller (such as Arduino), enabling wireless communication between the trimmer and a mobile application. The mobile app, developed using platforms like MIT App Inventor or Flutter, provides users with the ability to control the trimmer's movement, speed, and operational functions through Bluetooth, offering a convenient and intuitive user experience.

The trimmer is equipped with an ultrasonic sensor to detect obstacles in its path, ensuring safe and precise navigation. The sensor data is processed by the microcontroller, which adjusts the trimmer's movement when obstacles are detected. The trimmer's movement is controlled by a servo motor, enabling it to follow a snake-like pattern to cover the lawn area efficiently while minimizing energy consumption. The cutting mechanism uses a rotating blade powered by the solar-charged battery to trim the grass. The mobile app also displays real-time feedback on the trimmer's operational status, including battery levels. Finally, extensive testing is carried out to evaluate the system's performance, including solar panel efficiency, Bluetooth communication range, obstacle detection accuracy, and overall movement. Based on the test results, adjustments are made to optimize system performance, reliability, and user experience.

3. LITERATURE REVIEW

Recent advancements in automation, renewable energy, and wireless communication have led to the development of smart lawn maintenance systems aimed at improving efficiency while reducing environmental impact. Various researchers have proposed solar-powered and autonomous grass cutters with diverse control mechanisms and features.

Ramya et al. (2021) introduced a solar-powered grass cutter integrated with a water-spraying system, using RF technology for remote control. Their system operated on a 12V DC battery and contributed to reduced air and noise pollution. However, it lacked mobile-based control and real-time navigation adaptability. Similarly, Habib et al. (2019) developed an automatic solar cutter with a PID controller and color sensor for autonomous movement. While effective in grass detection, the system did not incorporate mobile control or Bluetooth communication, limiting user interaction.

Sasikumar et al. (2024) presented an IoT-enabled grass cutter powered by solar energy and controlled via Wi-Fi, incorporating ultrasonic sensors for obstacle detection. Although the model demonstrated high efficiency in large areas like parks and stadiums, its complexity and reliance on continuous internet access made it less practical for basic, user-friendly lawn trimming. In contrast, Bhaskar et al. (2023) proposed a fully automated solar grass cutter with IoT integration. It focused on autonomous operation with minimal human involvement, but lacked the flexibility of switching to manual control when necessary.

Kanase et al. (2021) and Dalal et al. (2016) emphasized the environmental benefits of solar-powered cutting systems. These designs used simple motor-based mechanisms and manual switches for operation, making them more affordable but less adaptive to dynamic navigation challenges. Manimegalai et al. (2019) expanded the functionality by incorporating pesticide spraying and alphabet printing in their grass cutter, showcasing multi-purpose applications, but at the cost of increased mechanical complexity.

Meghpuje et al. (2023) developed a hybrid solar grass cutter capable of operating in both manual and automatic modes. While this system offered flexibility, it lacked real-time feedback and mobile-based controls. Ghorpade et al. (2018) built an intelligent cutter using an ARM controller and ultrasonic sensors, achieving precise movement and obstacle avoidance but without a user-friendly interface.

Most of the reviewed systems demonstrate strong progress in energy efficiency and autonomous navigation. However, few have combined solar power, obstacle avoidance, and Bluetooth-enabled mobile control in a compact, cost-effective design suitable for small to medium lawns. The proposed system bridges this gap by introducing a mobile-controlled solar lawn trimmer with dual operation modes, a square path navigation algorithm, and real-time obstacle detection, all managed through an Arduino-based embedded platform. This positions the design as a scalable, eco-friendly, and user-centric alternative to traditional and partially automated systems.

4. PROPOSED SYSTEM

The proposed work aims to design and develop a mobile-controlled solar-powered lawn trimmer that integrates renewable energy with advanced automation for efficient lawn care. The first step involves the selection and integration of a solar panel capable of efficiently charging a rechargeable battery, ensuring the trimmer operates without reliance on external power sources. The system will include a Bluetooth module for wireless communication, allowing users to control the trimmer's movement via a mobile application, providing ease of use and flexibility.

To enhance the system's safety and precision, an ultrasonic sensor will be incorporated to detect obstacles in the trimmer's path, automatically adjusting its movement to avoid any potential damage to plants or structures. Additionally, the trimmer's design will focus on optimizing its movement pattern, ensuring maximum area coverage while minimizing energy consumption. The cutting mechanism will be engineered for efficient grass trimming, powered by the energy collected through solar panels.

Finally, comprehensive testing will be conducted to assess the performance of the solar power system, Bluetooth control, ultrasonic sensor, and overall trimmer operation under varying conditions. Based on the testing results, necessary optimizations will be made to enhance the trimmer's efficiency, reliability, and user experience.

5. BLOCK DIAGRAM

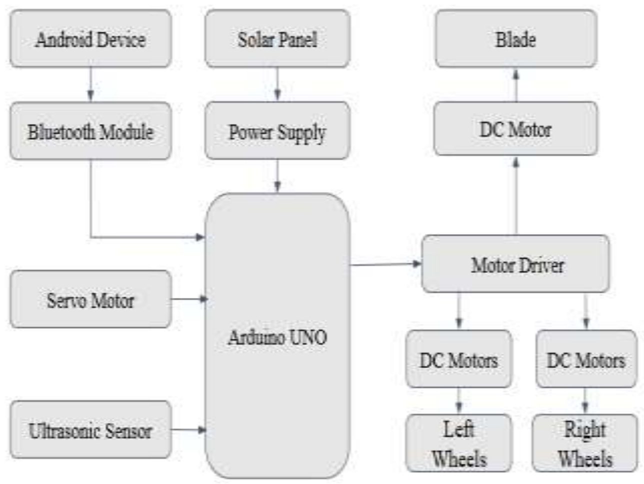

Fig -1: Block diagram of mobile controlled solar lawn trimmer

The block diagram of the mobile-controlled solar lawn trimmer illustrates the structured integration of key components enabling efficient and autonomous grass cutting using renewable energy. At the heart of the system is the Arduino UNO microcontroller, which serves as the central processing unit, coordinating all operations including motor control, obstacle detection, and communication. The system is powered by a solar panel rated between 10W to 20W, capable of generating 7V–12V DC, which charges a 7Ah rechargeable lithium-ion battery. This setup ensures continuous operation even in cloudy or low-light conditions, promoting energy sustainability.

The trimmer supports dual operational modes—manual and automatic. In manual mode, a Bluetooth module (HC-05) enables wireless communication between a smartphone and the Arduino, allowing users to control movement and blade activation through a mobile application. Directional commands such as forward, backward, left, and right are transmitted via the app and interpreted by the Arduino to execute precise movements.

In autonomous mode, an ultrasonic sensor (HC-SR04) is used to detect obstacles in the trimmer's path. It emits ultrasonic waves and calculates the time taken for the echo to return, thus determining the distance of nearby objects. If an obstacle is detected, the Arduino redirects the trimmer accordingly to avoid collisions and resume its square path movement. A servo motor is used to rotate the ultrasonic sensor, expanding its field of detection for improved navigation accuracy.

The system's locomotion and cutting mechanism are powered by DC motors, which are controlled via an L298N motor driver. One set of motors drives the wheels for movement, while another powers the cutting blade. The motor driver allows bidirectional control and variable speed regulation, ensuring efficient navigation and effective grass trimming. The blade, fabricated from high-strength steel and mounted on a high-speed DC motor shaft, rotates at 3000–5000 RPM to perform precise and uniform grass cutting.

All components are interconnected in a closed-loop feedback system where inputs—whether from sensors or user commands—are processed in real-time by the Arduino. The system then activates appropriate outputs such as motor rotation or directional adjustment. This seamless hardware-software integration, powered by solar energy, provides an eco-friendly, cost-effective, and intelligent solution for modern lawn maintenance.

6. CIRCUIT DIAGRAM

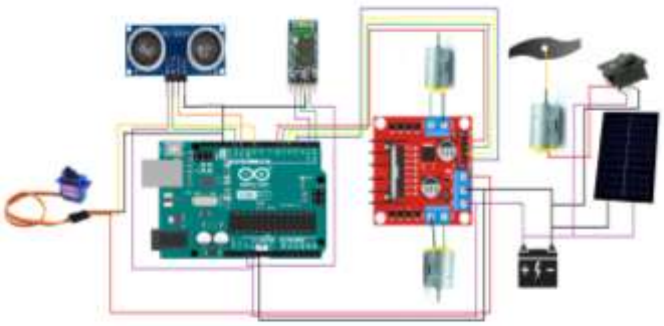

Fig -2: Circuit diagram of mobile controlled solar lawn trimmer

7. WORKING

The mobile controlled solar lawn trimmer is developed using a systematic approach that integrates solar energy, microcontroller-based control, and wireless communication. The methodology involves both hardware and software components working together to achieve autonomous grass trimming.

First, solar energy is harvested using a photovoltaic panel and stored in a rechargeable battery. This energy powers the entire system, including motors, sensors, and the Arduino Uno microcontroller. The Arduino acts as the central processing unit, receiving inputs from the Bluetooth module and ultrasonic sensor, and producing output signals to control the motor driver and actuators. The system follows a square path for efficient area coverage. Movement commands are programmed into the Arduino using an algorithm that reduces the path size progressively after each loop, forming a spiral-like pattern. The ultrasonic sensor mounted on a servo motor continuously scans the front area to detect obstacles. If an object is detected, the system temporarily halts and redirects the path to avoid collisions.

A Bluetooth module (HC-05) is integrated for manual control through a mobile application. This allows the user to switch between automatic and manual modes. The mobile app sends directional commands wirelessly, which are interpreted by the Arduino to control motor functions. The system is built on a lightweight chassis with motorized wheels for mobility and rotating stainless-steel blades for cutting grass. The combination of sensor feedback, programmed logic, and user input ensures flexible, safe, and efficient operation.

8. SQUARE PATH ALGORITHM

The autonomous operation of the mobile-controlled solar lawn trimmer is governed by a square path movement algorithm. This method is designed to systematically cover the entire lawn area by directing the trimmer in a series of concentric square loops, gradually reducing the coverage area toward the center. Initially, the system sets a predefined side length for the outermost square based on the dimensions of the lawn. The trimmer begins moving forward along this length, and upon reaching the end of one side, it performs a precise 90-degree right turn. This sequence is repeated four times to complete a full square loop.

After completing each loop, the side length is reduced by a fixed decrement, and the process continues inward. This inward spiraling movement ensures comprehensive coverage of the lawn without redundancy or untrimmed patches. Throughout the operation, the ultrasonic sensor plays a critical role by continuously monitoring for obstacles. If an obstacle is detected within a specific range, the system halts movement and redirects the trimmer either left or right to bypass the obstruction before resuming the square path. This ensures smooth, collision-free operation without user intervention.

The algorithm continues until the side length falls below a defined threshold, indicating that the center of the lawn has been reached. At this point, the system automatically stops. The square path algorithm not only enhances trimming efficiency but also optimizes battery usage and motor workload by avoiding unnecessary overlapping paths. Its structured approach, combined with real-time obstacle detection, makes it highly effective for residential lawn automation.

9. RESULT

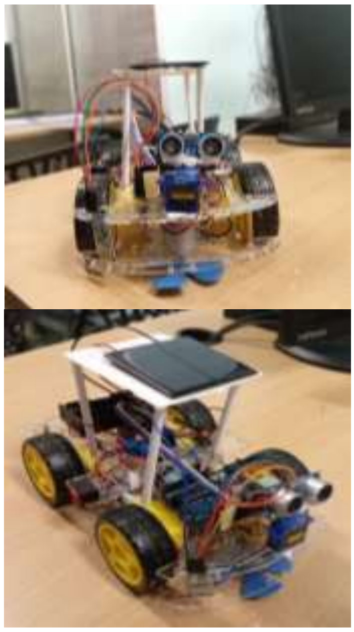

Fig -3: Output of Mobile controlled Solar Lawn Trimmer

The developed mobile-controlled solar lawn trimmer was tested under various conditions to evaluate its performance, including solar power efficiency, Bluetooth control range, obstacle detection accuracy, and overall functionality. The solar panel successfully charged the rechargeable battery under different sunlight conditions, providing consistent power to the trimmer. In full sunlight, the solar panel was able to charge the battery sufficiently for the trimmer to operate for extended periods without requiring additional charging. In partial sunlight, the trimmer operated for a shorter duration, but the battery was still able to sustain its function for a reasonable time, demonstrating the system's ability to operate in diverse lighting conditions.

The Bluetooth control system demonstrated reliable communication between the mobile app and the trimmer. The Bluetooth range was tested to be effective within a 10-meter radius, allowing users to control the trimmer from a reasonable distance. The mobile app provided a user-friendly interface, enabling smooth control over the trimmer's movement, speed, and on/off functionality. The obstacle detection system, powered by the ultrasonic sensor, effectively detected objects in the trimmer's path. The trimmer automatically adjusted its direction when obstacles were detected, ensuring safe operation and preventing collisions with plants and structures.

During testing, the trimmer's movement pattern was found to be efficient, with the servo motor enabling smooth navigation. The snake-like movement ensured maximum area coverage with minimal overlap, optimizing the trimming process. The cutting mechanism performed well, providing clean and precise grass trimming. The overall system showed promising results in terms of energy efficiency, ease of use, and safety. The final system design successfully met the objectives of the project, demonstrating the potential for a sustainable and user-friendly solution for lawn maintenance.

10. FUTURE SCOPE

The mobile-controlled solar lawn trimmer presents numerous opportunities for further enhancement and expansion. One of the primary areas for improvement is the integration of more advanced energy storage systems, such as lithium-ion or lithium-polymer batteries, which would offer longer operational times and faster charging cycles. Additionally, further optimization of the solar panel's efficiency could allow the trimmer to operate for extended periods in various weather conditions, even with limited sunlight.

Another avenue for development lies in the refinement of the navigation system. Future versions could incorporate advanced sensors, such as LIDAR or computer vision, for more precise obstacle detection and navigation, enabling the trimmer to adapt to complex landscapes and environments. Moreover, machine learning algorithms could be implemented to improve the trimmer's ability to map the lawn and learn optimal mowing patterns, resulting in even more efficient operation. The potential for smart home integration also exists, where the trimmer could be controlled via voice assistants like Amazon Alexa or Google Assistant.

Additionally, there is the possibility of scaling the design for larger residential or commercial lawns, where the trimmer could be designed to cover larger areas with minimal human intervention. Enhancements in the cutting mechanism, such as adjustable height settings and various blade options, would provide versatility for different types of lawns. Finally, the incorporation of data analytics and remote monitoring could allow users to track the trimmer's performance, maintenance needs, and energy usage, making the system even more user-friendly and efficient.

11. CONCLUSION

The mobile-controlled solar lawn trimmer developed in this project successfully integrates renewable energy with automation to offer an efficient and sustainable solution for lawn maintenance. The system demonstrates the potential of using solar power to operate a lawn trimmer without the need for external electrical sources, making it both environmentally friendly and cost-effective. The Bluetooth-controlled interface allows users to manage the trimmer remotely, providing convenience and flexibility in operation, while the ultrasonic sensor ensures safety by detecting obstacles in the trimmer's path.

Through rigorous testing, the system has proven to be effective in terms of power efficiency, ease of use, and overall functionality. The solar power system charges the trimmer reliably under varying sunlight conditions, and the mobile app provides intuitive control. The trimmer's movement pattern ensures efficient coverage of the lawn, while the cutting mechanism delivers precise and clean trimming results. This project opens the door for further enhancements, including smarter navigation, improved energy storage, and larger-scale applications. The mobile-controlled solar lawn trimmer represents a step forward in automated gardening solutions, offering a sustainable and user-friendly approach to lawn care.

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