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Smart Solar Grass Cutting Robot

Ms. Mitali S. Chavan [1], Ms. Tanvi S. Mestry[2], Ms. Bhumika S. Satardekar[3], Ms. Malini B. Warang [4], Ms. Gauri N. Rawool [5], Mrs. Shital A. Palav [6]

[12345]Students, Yashwantrao Bhonsale Institute of Technology, Sawantwadi, Maharashtra, India

[6] Faculty, Yashwantrao Bhonsale Institute of Technology, Sawantwadi, Maharashtra, India

[1]mitalichavan2005@gmail.com, [2]warangmalini0601@gmail.com , [3]gaurirawool234@gmail.com

Abstract:

Agriculture is increasingly facing challenges such as labour shortages, rising fuel costs, and the need for environmentally sustainable practices. Traditional methods of grass cutting, seed sowing, and irrigation require continuous human effort and are often inefficient, time-consuming, and expensive. To overcome these limitations, automation combined with renewable energy has emerged as an effective solution.

The Smart Solar Grass Cutting Robot (SSGCR) is designed as a multi-functional agricultural robot that operates using solar energy. The system integrates several farming operations such as grass cutting, seed sowing, water or pesticide spraying, and soil moisture monitoring into a single robotic platform. The robot is powered by a solar panel coupled with a rechargeable battery, enabling it to function independently without relying on fossil fuels or grid electricity.

An Arduino Uno microcontroller serves as the central control unit, coordinating the operation of motors, sensors, and actuators. Wireless control is achieved using a Bluetooth module, allowing the user to operate the robot through a smartphone application. Obstacle detection is implemented using ultrasonic sensor to ensure safe and reliable operation in real agricultural environments.

The proposed system reduces manual labour, minimizes operational costs, and decreases environmental pollution. Experimental results and observations indicate efficient task execution, low power consumption, and improved safety. The Smart Solar Grass Cutting Robot provides a cost-effective, eco-friendly, and user-friendly solution for modern agriculture and lawn maintenance, particularly suitable for rural and remote areas.

Keywords— Smart Agriculture, Solar Energy, Grass Cutting Robot, Agricultural Automation, Bluetooth Control, Multi-Functional Robot

I. INTRODUCTION

Agriculture is one of the most important sectors for the survival and economic growth of any country. It provides food, employment, and raw materials for various industries. With the rapid growth of population, the demand for agricultural production has increased significantly. To meet this growing demand, farmers are required to produce more crops in less time and at lower costs. However, traditional farming methods still rely heavily on manual labour, making agricultural operations slow, inefficient, and physically demanding [1].

Grass cutting, seed sowing, and irrigation are essential activities in farming and lawn maintenance. Traditionally, these tasks are performed manually or using fuel-powered machines. Manual methods require continuous human effort and are time-consuming, while fuel-based machines increase operational costs and cause environmental pollution [6]. In addition, rising fuel prices and irregular electricity supply in rural areas make conventional agricultural equipment unreliable and expensive.

Technological advancements in robotics, embedded systems, and communication technologies have created new opportunities to modernize agriculture. Automation in farming helps reduce labour dependency, improve accuracy, and increase overall productivity [7]. Among various energy sources, solar energy has gained significant importance due to its availability, low cost, and eco-friendly nature. Solar-powered systems are especially suitable for agricultural applications in rural and remote areas [2] where electricity supply is limited.

The Smart Solar Grass Cutting Robot (SSGCR) is developed to address these challenges by combining automation with renewable energy. The robot is designed to perform multiple agricultural tasks such as grass cutting, seed sowing, water or pesticide spraying, and soil moisture monitoring. It is powered by a solar panel and rechargeable battery, allowing continuous operation without external power sources.

The robot is controlled wirelessly using Bluetooth technology through a smartphone application, making it easy to operate even for users with minimal technical knowledge. An Arduino Uno microcontroller acts as the brain of the system, controlling motors, sensors, and other components [2]. Obstacle detection sensors ensure safe operation by preventing collisions in the field.

Thus, the Smart Solar Grass Cutting Robot represents a step toward sustainable, efficient, and smart agricultural practices by reducing human effort, lowering costs, and minimizing environmental impact.

II. LITERATURE REVIEW

Several researchers have worked on agricultural automation, solar-powered machines, and robotic systems to reduce human effort and improve farming efficiency. This section reviews important research work related to the Smart Solar Grass Cutting Robot and identifies the research gap [1].

Many studies focus on solar-powered grass cutting machines, highlighting their ability to reduce fuel consumption and

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environmental pollution. These systems mainly use solar panels and rechargeable batteries to power cutting motors [6]. While they are eco-friendly, most of these machines are designed only for grass cutting and do not support additional agricultural operations [1].

Research on Bluetooth-controlled agricultural robots demonstrates the effectiveness of wireless communication for short-range control. Bluetooth-based systems are cost-effective, easy to implement, and user-friendly [2]. However, such systems often depend on manual control and lack advanced automation or multi-functionality.

Several researchers have developed robotic lawn mowers using GPS and predefined navigation paths. These robots are effective for urban lawns and parks, but they are expensive and not suitable for small farmers or uneven agricultural fields [1]. Additionally, they are usually designed for single-task operation.

Studies on solar-powered irrigation and soil monitoring robots emphasize energy efficiency and sustainability. These robots help optimize water usage and reduce power consumption [5]. However, most of these systems are limited to irrigation or monitoring and cannot perform mechanical tasks like grass cutting or seed sowing [9].

Research related to obstacle detection and safety systems uses ultrasonic and infrared sensors to improve reliability in outdoor environments. While these systems enhance safety, they are often implemented in high-cost autonomous robots.

From the literature survey, it is observed that there is a lack of low-cost, solar-powered, multi-functional agricultural robots that can perform multiple tasks such as grass cutting, seed sowing, spraying, and monitoring. The Smart Solar Grass Cutting Robot aims to bridge this gap by integrating multiple agricultural functions into a single, affordable, and energy-efficient system [4].

III. OBJECTIVES

a. To develop a solar-powered agricultural robot.

b. To automate grass cutting operations.

c. To integrate multiple agricultural functions.

d. To reduce labour dependency and operational cost.

e. To implement wireless control using Bluetooth technology.

f. To improve safety using obstacle detection.

g. To promote sustainable and eco-friendly farming.

IV. METHODOLOGY

The methodology describes the systematic approach followed to design, develop, and implement the Smart Solar Grass Cutting Robot. The project is divided into several functional modules to ensure efficient operation and easy integration of components [2].

1. System Design and Architecture

The overall system is designed using a modular approach consisting of a power module, control module, mobility module, cutting mechanism, multi-functional units, and safety module. Each module performs a specific function and works together to achieve automated agricultural operations [3].

2. Power Supply Module

A solar panel is mounted on the robot to capture solar energy and convert it into electrical energy. This energy is stored in a rechargeable battery, which supplies power to the Arduino microcontroller, motors, sensors, and other electronic components. This ensures uninterrupted operation even when sunlight is temporarily unavailable.

3. Control Unit

An Arduino Uno microcontroller acts as the brain of the robot. It processes input commands received via the Bluetooth module and controls the operation of DC motors, servo motors, cutting blade, water pump, and sensors according to the programmed logic [3].

4. Mobility System

DC motors are used to drive the wheels of the robot, enabling movement in forward, backward, left, and right directions. Motor driver circuits are used to control speed and direction based on user commands.

5. Grass Cutting Mechanism

A motor-driven rotary cutting blade is installed at the bottom of the robot. The blade rotates at high speed to cut grass efficiently and uniformly. The cutting height can be adjusted as required.

6. Multi-Functional Operations

- Seed Sowing Mechanism: A servo motor controls a seed dispenser that releases seeds at regular intervals.
- Water/Pesticide Spraying: A mini water pump sprays water or pesticides evenly over the field.
- Moisture Monitoring: A moisture sensor measures soil moisture levels to avoid operation in overly wet conditions.

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7. Obstacle Detection and Safety

Ultrasonic sensors detect obstacles such as stones, plants, or animals. When an obstacle is detected, the robot either stops or changes direction automatically, ensuring safety and preventing damage [9].

8. Wireless Communication

A Bluetooth module (HC-05/HC-06) enables wireless communication between the robot and a smartphone application. The user sends control commands, which are interpreted by the Arduino for real-time operation. Units, clearly state the units for each quantity in an equation

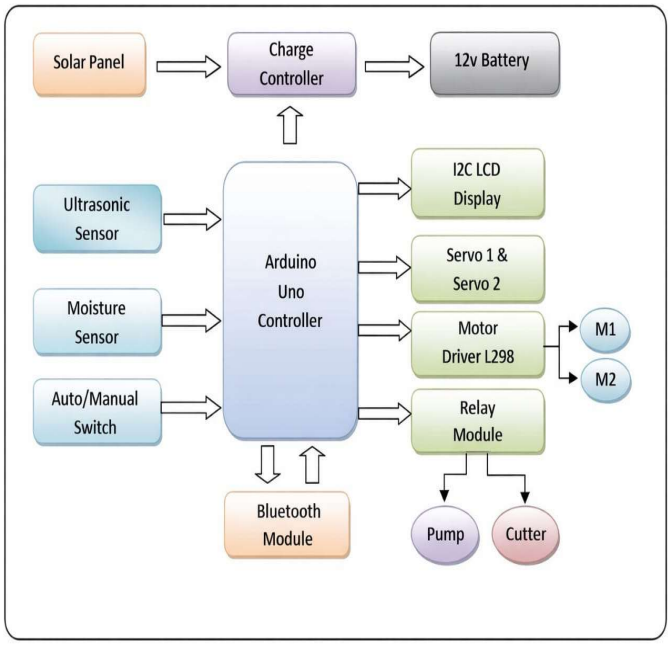

Fig 4. Block Diagram of Smart Solar Grass Cutting Robot

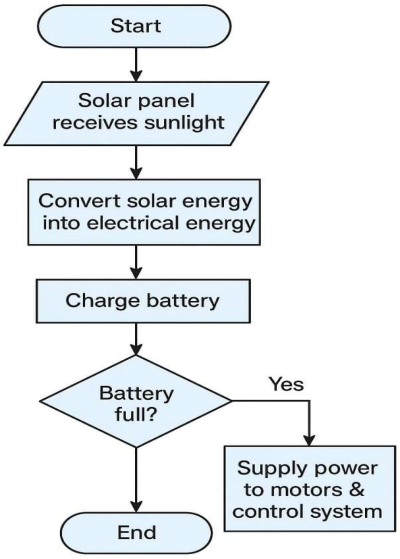

Fig1. Flowchart of Power Module

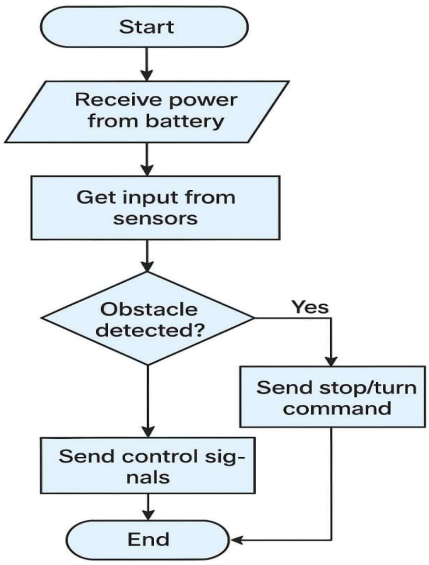

Fig 2. Flowchart of Control Module

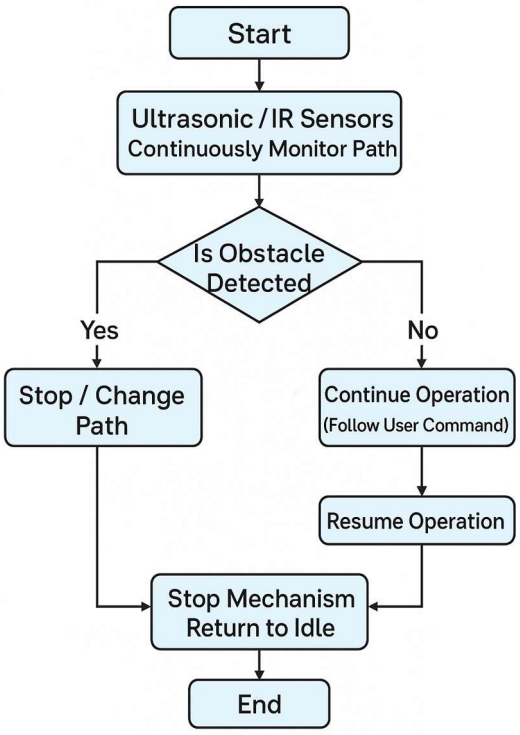

Fig 3. Flowchart of Obstacle detection

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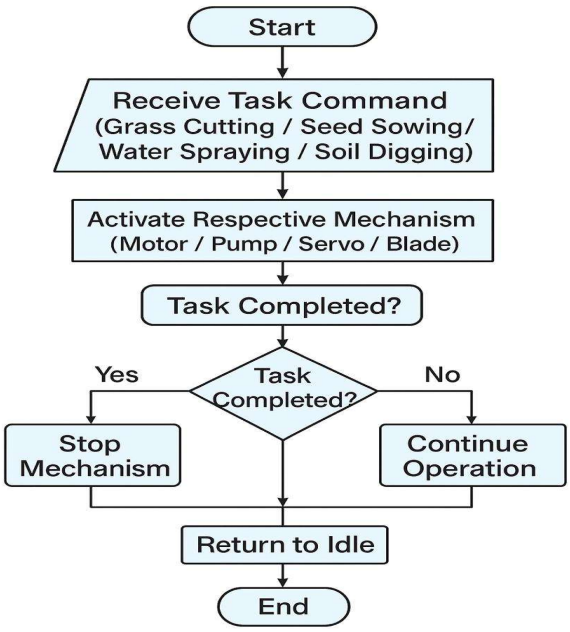

Fig 4. Flowchart of Smart Operation Module

V. DISCUSSION

The Smart Solar Grass Cutting Robot demonstrates how automation and renewable energy can be effectively combined to improve agricultural operations. The use of solar energy as the primary power source significantly reduces dependence on fossil fuels and grid electricity. This makes the system economical and environmentally friendly, especially for rural areas where electricity supply is unreliable [1].

The multi-functional design of the robot allows it to perform several agricultural tasks such as grass cutting, seed sowing, water or pesticide spraying, and soil moisture monitoring using a single machine. This reduces the need for multiple tools and machines, thereby lowering equipment costs and maintenance requirements. Wireless Bluetooth control provides ease of operation, enabling farmers to control the robot in real time using a smartphone The inclusion of obstacle detection enhances safety and reliability in real field conditions. Ultrasonic sensors help prevent collisions with obstacles such as stones, plants, or animals, reducing the risk of damage to the robot and the environment. The modular design also allows future upgrades and easy troubleshooting.

However, the system has certain limitations. The robot's performance depends on the availability of sunlight, and prolonged cloudy conditions may affect battery charging. Additionally, Bluetooth communication has a limited operating range, which restricts long-distance control. Despite these limitations, the robot performs efficiently for small and medium-scale agricultural applications.

Overall, the Smart Solar Grass Cutting Robot proves to be a practical, low-cost, and sustainable solution for agricultural automation. It successfully meets its design objectives and demonstrates the potential for further improvements through advanced technologies.

VI. CONCLUSION

The Smart Solar Grass Cutting Robot represents a significant step toward the modernization of agricultural practices through automation and renewable energy integration. The project successfully demonstrates the design and implementation of a multi-functional agricultural robot capable of performing grass cutting, seed sowing, water or pesticide spraying, and soil moisture monitoring. By utilizing solar energy as the primary power source, the system reduces dependence on fossil fuels and conventional electricity, making it environmentally friendly and cost-effective [2].

The use of an Arduino-based control system combined with Bluetooth communication ensures simple and user-friendly operation. Farmers can easily control the robot using a smartphone application without requiring advanced technical knowledge. The inclusion of obstacle detection sensors improves safety and reliability, allowing the robot to operate effectively in real agricultural environments.

The project achieves its main objectives of reducing manual labour, minimizing operational costs, and promoting sustainable farming practices. Although the system has certain limitations, such as dependency on sunlight and limited Bluetooth range, these can be addressed in future enhancements by incorporating technologies like GPS navigation, IoT-based remote monitoring, and higher-capacity energy storage [8].

In conclusion, the Smart Solar Grass Cutting Robot provides a practical, affordable, and eco-friendly solution for small and medium-scale agricultural applications. The successful implementation of this project highlights the potential of smart and sustainable technologies in transforming traditional agriculture into a more efficient and modern system.

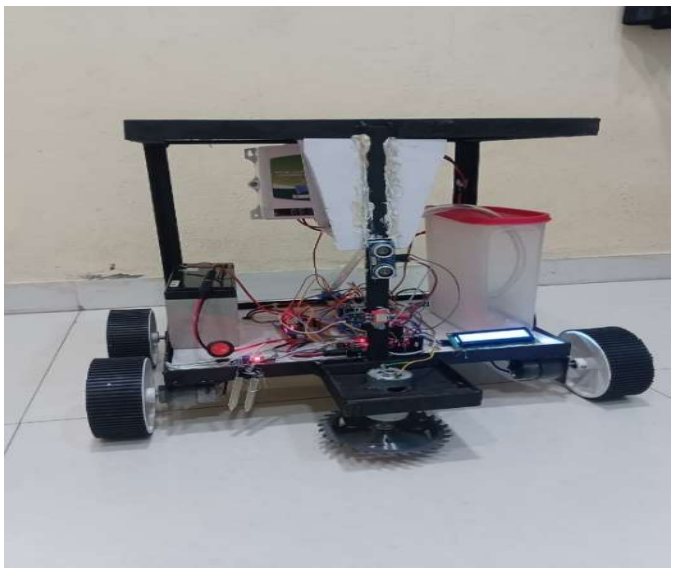

Fig 1. Front view of Smart Solar Grass Cutting Robot

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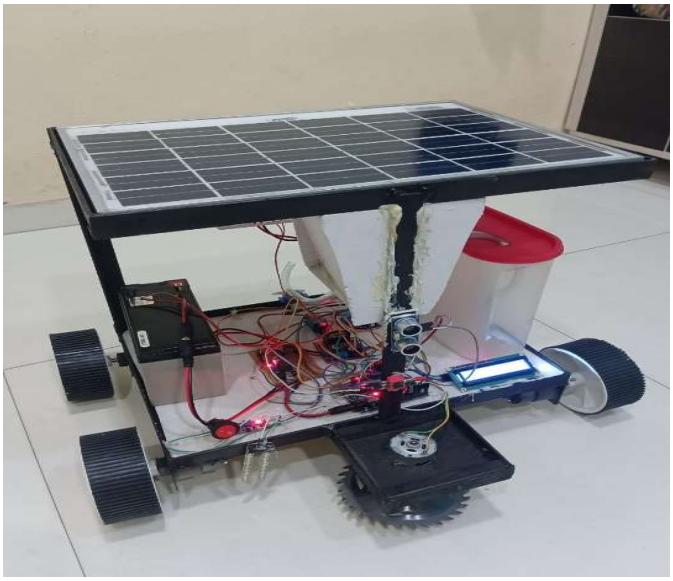

Fig 2.Top View of Smart Solar Grass Cutting Robot

Fig 3. Mobile Application of Seed Spray Controller

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