

Development of a Multi-Purpose Agricultural Robot for Smart Farming

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Abstract - The project "Development of a Multi-Purpose Agricultural Robot for Smart Farming" is designed to support modern agriculture through automation and renewable energy. The robot performs important farming activities such as grass cutting, seed sowing, soil moisture monitoring, automatic irrigation, and obstacle detection with minimal human involvement. The system is controlled using an Arduino UNO microcontroller, which manages all sensors and hardware components efficiently. The robot is powered by solar energy, making it suitable for agricultural areas with limited access to electricity while also reducing operational costs and energy consumption. Its movement is controlled using DC gear motors and an L298N motor driver, while wireless operation is achieved through an HC-05 Bluetooth module connected to a mobile application. An ultrasonic sensor helps the robot avoid obstacles, and a soil moisture sensor automatically activates the irrigation pump whenever the soil becomes dry. A servo motor is used for accurate seed dispensing during sowing operations. The project demonstrates a cost-effective, eco-friendly, and efficient farming solution that improves productivity and supports sustainable agriculture. It also creates opportunities for future improvements such as GPS navigation, IoT-based remote monitoring, and AI-driven smart farming technologies.

Keywords: Smart Farming , Agricultural Robot, Arduino UNO, Solar Energy, Automation , Soil Moisture Sensor.

1. INTRODUCTION

Agriculture has long been a major pillar of the Indian economy, supporting the livelihood of a large portion of the population. In recent times, however, farmers have been facing several difficulties, including shortage of labor, rising farming expenses, uneven crop productivity, and the increasing need for efficient and sustainable agricultural techniques. Conventional farming methods that rely heavily on manual labor are time-consuming, physically exhausting, and often lead to inefficient use of resources. With continuous technological development,

automation and robotics have become important innovations in the agricultural sector. The use of embedded systems, sensors, and renewable energy technologies allows farmers to monitor and manage farming activities more effectively while reducing manual effort. Combining robotics with solar energy offers a practical solution for creating autonomous agricultural systems capable of carrying out multiple tasks such as seed sowing, irrigation, and grass cutting in an environmentally friendly and energy-efficient way. The proposed Solar-Based Agriculture Robot is developed to overcome these agricultural challenges by integrating automation, renewable energy, and intelligent control systems to promote smart and sustainable farming practices.

2. Body of Paper

2.1 Methodology

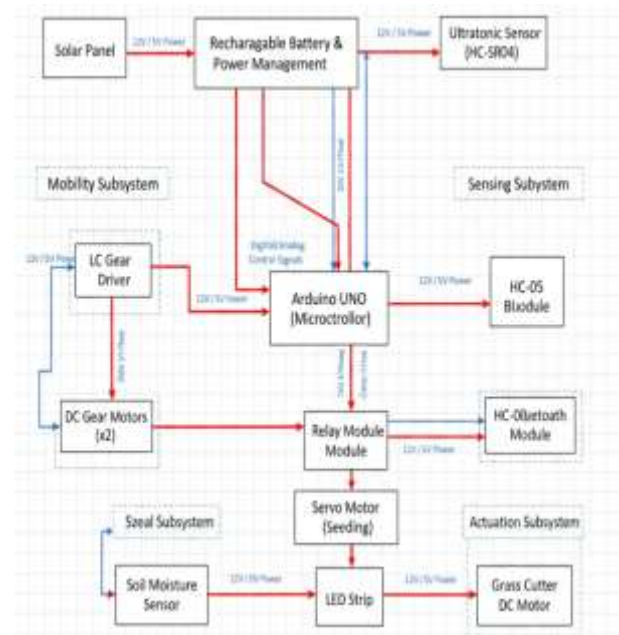


Fig 2.1 Block Diagram

The proposed project, Solar-Based Multipurpose Agricultural Robot, integrates renewable energy with automation to assist farmers in routine agricultural

operations such as ploughing, seeding, grass cutting, irrigation, and obstacle detection. The entire system is powered through solar energy, ensuring sustainability, low operational cost, and energy independence in rural regions. This chapter describes the design approach, working principle, and detailed functioning of each subsystem of the robot.

The overall architecture integrates power management, control, actuation, and sensing subsystems. The power management unit ensures continuous operation using solar energy.

- The control unit (Arduino UNO) executes programmed logic and sends actuation commands.
 - The actuation subsystem drives motors and relays.
 - The sensing subsystem continuously monitors environmental parameters like distance and soil moisture.
- This modular structure allows easy debugging, maintenance, and future scalability.

2.2 Modeling and Analysis

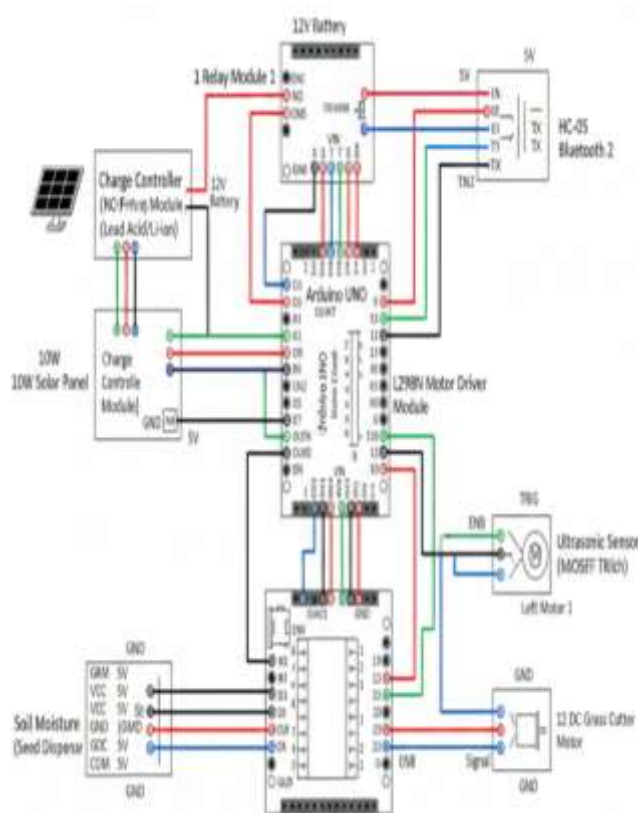


Fig 2.2 Circuit Diagram

The given circuit diagram represents a **Solar-Based Multi-Purpose Agricultural Robot** designed for smart farming applications. The system integrates renewable energy, automation, sensing technology, and wireless communication to perform agricultural tasks efficiently

with minimal human effort. At the core of the system is the Arduino UNO, which acts as the main controller for coordinating all connected modules and sensors. It receives input signals from sensors and controls the motors, relay, and communication modules according to programmed instructions. The power supply section consists of a **10W solar panel**, a **charge controller module**, and a **12V battery**. The solar panel converts sunlight into electrical energy, while the charge controller regulates charging and protects the battery from overcharging or deep discharge. The stored battery power ensures continuous operation even during low sunlight conditions, making the system energy-efficient and suitable for remote agricultural areas.

The robot's movement is controlled using an L298N Motor Driver Module connected to DC motors. The motor driver receives control signals from the Arduino UNO and drives the motors in forward, reverse, left, and right directions. This arrangement allows smooth mobility of the robot in agricultural fields. Wireless communication is provided through the HC-05 Bluetooth Module. It enables the user to control and monitor the robot through a mobile application. The TX and RX pins establish serial communication between the Bluetooth module and the Arduino controller. An ultrasonic sensor is connected for obstacle detection and collision avoidance. The sensor continuously measures the distance between the robot and nearby objects using trigger and echo signals. If an obstacle is detected within a certain range, the robot can stop or change direction automatically, improving operational safety.

The circuit also includes a soil moisture sensor used to monitor soil water content. When the soil moisture falls below a predefined level, the Arduino activates the irrigation mechanism automatically. This helps maintain proper soil conditions while conserving water resources. A relay module is used to control high-power devices such as the grass cutter motor and water pump. Since these components require higher current than the Arduino can provide directly, the relay acts as an electrically controlled switch. The 12V DC grass cutter motor is connected through this relay arrangement to perform cutting operations efficiently. Additionally, the system includes a seed dispensing mechanism controlled through motor signals for automated seed sowing. The integration of multiple farming functions into a single robotic platform increases productivity and reduces manual labor.

2.3 Result and Discussion

This chapter explains the results and performance of the Solar-Based Agriculture Robot developed for smart farming applications. The robot was tested in different indoor and outdoor agricultural conditions to evaluate its efficiency, accuracy, and reliability. It successfully

performed operations such as movement, seed sowing, grass cutting, irrigation, and obstacle detection.

The system integrated components like Arduino UNO, motor driver, Bluetooth module, ultrasonic sensor, soil moisture sensor, relay modules, solar-powered battery system, grass cutter, and seed dispenser. The solar panel provided sustainable power, while LED lights improved visibility during operation.

Testing showed stable hardware integration and smooth coordination between sensors, motors, and actuators. The ultrasonic sensor provided accurate obstacle detection with an accuracy of ± 2 cm, and Bluetooth control remained stable within 8–10 meters. The robot consumed low power and operated continuously for 2–3 hours with solar charging support.

Overall, the prototype demonstrated reliable and energy-efficient performance for small-scale farming tasks. The use of solar energy and automation reduced manual labor and supported sustainable agriculture. The modular design also allows future upgrades such as GPS, AI, and IoT integration for advanced smart farming applications.

3. CONCLUSIONS

The project “Solar-Based Agriculture Robot” was successfully developed and implemented to automate important farming activities using renewable solar energy. The system combined sensors, actuators, and Arduino UNO-based control programming to perform tasks such as obstacle sensing, automatic stopping, grass trimming, soil moisture-controlled irrigation, seed sowing, and wireless Bluetooth operation.

The robot proved the practicality of small-scale agricultural automation by reducing manual effort and supporting sustainable energy usage. All major objectives of the project, including automation, mobility, multi-purpose functionality, and solar power utilization, were successfully achieved through proper hardware and software integration.

Performance testing showed efficient operation in all functions. The robot provided accurate obstacle detection, smooth motor movement, stable Bluetooth communication, and reliable irrigation based on soil moisture levels. The solar charging system effectively powered the robot during daytime operation, while the servo-based seed dispensing mechanism ensured proper seed placement.

Overall, the system demonstrated satisfactory performance, low energy consumption, and reliable operation, confirming its potential as an energy-efficient and self-sustaining agricultural assistant for smart farming applications.

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