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Smart Solar Powered Web Controlled Multi-function Agribot

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***Abstract* - Agriculture remains vital to human survival and economic growth, yet traditional farming practices are labour-intensive, time-consuming, and inefficient[1]. To address this challenge, this paper presents a solar-powered, mobile-controlled multipurpose agricultural robot using Arduino. The system performs key agricultural operations including soil digging, seed sowing, watering, and grass cutting, controlled through a Bluetooth-enabled Android application. Solar energy powers the robot, enabling continuous operation even in remote agricultural fields with limited access to electricity[2]. The system integrates sensors, DC motors, and actuators to execute tasks with precision, while the Arduino microcontroller functions as the central control unit for coordination of all modules[8]. The proposed solution reduces manual labour, operating time, and overall farming costs, making it a sustainable and affordable automation tool for small and medium-scale farmers[3]. This work demonstrates an efficient step toward smart agriculture and promotes renewable-energy-based automation for improved productivity and environmental sustainability[5].**

***Keywords* - Smart agriculture, Solar-powered agricultural robot, Arduino microcontroller, Multi-task farming system, Sustainable automation**

1. INTRODUCTION

Agriculture plays a crucial role in sustaining national economies and ensuring global food availability, especially in developing regions where it remains the primary source of income for many households[1]. Despite its importance, many farming processes are still performed manually, making activities such as sowing, irrigation, and vegetation management slow, labour demanding and prone to inefficiencies. Increasing labour shortages, higher operational expenses, and the urgent need to boost production further intensify these challenges[2]. In recent years, automation and robotics have emerged as effective solutions for improving precision and efficiency in agriculture. By enabling repetitive farming operations to be executed automatically, robotics supports faster and more accurate task completion.

This work introduces a solar-powered, Bluetooth controlled agricultural robot built around an Arduino microcontroller[2]. The robot can perform multiple field tasks seed placement, soil digging, watering, and grass cutting while being operated remotely through an Android application. Solar energy powers the system, allowing uninterrupted operation in remote or off-grid agricultural environments without dependency on external electricity[8]. Sensors, motors, and actuators are integrated to ensure accurate operation, and low-cost components are used to make the system affordable for small and medium-scale farmers[5]. The proposed design significantly reduces physical labour, shortens working time, and improves resource efficiency[1]. Overall, the system demonstrates how renewable energy and embedded automation can contribute to smart farming and lays the groundwork for future improvements such as IoT connectivity, autonomous movement, and intelligent field monitoring smarter and safer working environments that go beyond conventional safety equipment[3].

2. PROPOSED SOLUTION

The proposed system consists of a solar-powered agricultural robot that can be controlled through a mobile application and is capable of executing multiple field activities such as seed placement, watering, and grass trimming[8]. An Arduino microcontroller serves as the main processing unit and coordinates the actions of various sensors, motors, and actuators[2]. Energy for the system is supplied through a solar panel, which charges an onboard rechargeable battery, allowing the robot to function efficiently even in remote regions without stable electricity[4]. The Bluetooth-based mobile application enables wireless control, allowing the user to navigate the robot and activate different functions remotely[1]. The robot incorporates four functional modules: a seeding and sowing unit that drills the soil and dispenses seeds in a controlled manner, a watering unit consisting of a small pump and nozzle system operated through a relay, a grass cutting unit driven by a DC motor and equipped with a rotating blade, and a motion control unit using geared DC motors and an Arduino-based motor driver for directional movement[6]. All subsystems operate in coordination under Arduino control and ensuring smooth execution of tasks. This design reduces manual effort, increases efficiency, minimizes power usage, and provides a cost-effective automation solution for farmers, supporting the shift toward modern and sustainable agricultural practices.

3. BLOCK DIAGRAM

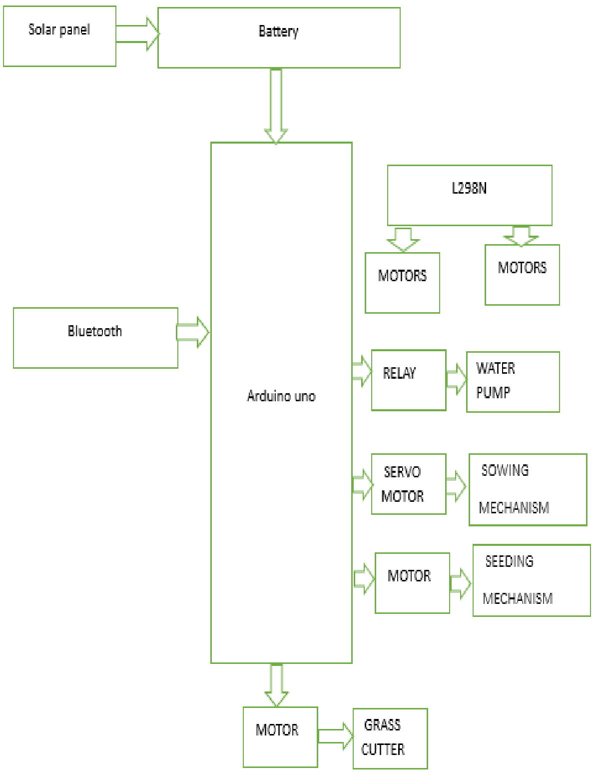

Fig 1.1 Block diagram

A 10W solar panel supplies power to the system by charging a 12V, 7000mAh battery through a charge controller.A voltage regulator (7805) converts the 12V supply to 5V for powering low-voltage components like Arduino and sensors.The Arduino Uno (ATmega328P) controls all modules, including motors, sensors, and actuators[3].The L293D motor driver module controls multiple DC motors for field operations such as digging, cutting, and wheel movement (M1–M5).Servo motors are used for precision tasks such as seeding, ploughing, and drill up/down movement.A 12V water pump (servo- controlled) is used for irrigation purposes.Temperature, humidity, and soil moisture sensors collect environmental data, which can be monitored wirelessly[2].Wi-Fi/Bluetooth (ThinkSpeak) module enables remote communication and control of the robot through a mobile or web interface.

4. HARDWARE SPECIFICATIONS

1. ARDUINO UNO

Fig 2.1 Ardunio board

Arduino Uno is a microcontroller development board built using the ATmega328P, designed for embedded control and automation applications. It operates at a regulated 5volt supply and features 14 digital input/output pins, of which 6 support PWM functionality, along with 6 analog input pins for reading sensor signals[4]. The board includes 32 KB of flash memory for program storage, 2 KB of SRAM for real-time data, and 1 KB of EEPROM for non-volatile storage. It runs at a clock frequency of 16 MHz, enabling stable and efficient execution of instructions[3]. The board can be powered using a USB connection or an external DC supply in the range of 7 to 12 volts, with an onboard voltage regulator ensuring safe operation even with input fluctuations[2]. Communication protocols such as UART, SPI, and I²C are supported, enabling easy interfacing with external modules like motor drivers, sensors, and wireless communication units. Indicator LEDs, a reset button, and standard pin headers simplify debugging and connectivity, making Arduino Uno a reliable controller for prototype development and robotics projects.

2. L298N Motor Driver Module

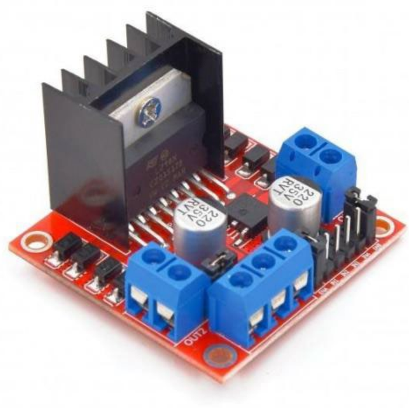

Fig 2.2 L298N Motor module

The L298N motor driver module is a dual H-bridge motor controller used to operate and control two DC motors independently[11]. It supports an input voltage range of

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approximately 5 to 35 volts and is capable of delivering up to 2 amperes of continuous current per channel. The module includes logic-level input pins to receive control signals from a microcontroller, allowing regulation of motor direction and speed[3][5]. Pulse width modulation (PWM) applied on the enable pins is used to vary the motor speed, while the output terminals provide the required current to the motors. An onboard voltage regulator enables the module to supply 5 volts for low- power circuitry when needed, and a heat sink helps dissipate heat generated during high-current operation. Due to its ability to interface low-power microcontrollers with higher-power motors, the L298N module is widely used in robotic and automation applications requiring reliable bidirectional motor control[1].

3. HC-05 BLUETOOTH MODULE

Fig 2.3 HC-05 Blutooth module

The HC-05 Bluetooth module is a low-power wireless communication device used to enable serial data exchange between a microcontroller and a smartphone. It operates in the 2.4 GHz ISM frequency band and supports UART communication with a configurable baud rate, with 9600 bps as the default. The module works on a voltage range of 3.3 V to 6 V, and onboard regulation ensures stable operation even when powered from a 5 V microcontroller[4]. It supports both master and slave modes, allowing flexible wireless control depending on the application. The integrated PCB antenna offers an effective transmission range of up to 10 meters in open environments[5]. Status LEDs on the module indicate pairing and connection status, which helps during debugging. In this system, the HC-05 module provides the wireless interface that allows the farmer to remotely control the robot's movements and operations using a mobile application[11].

4. DC Motor

Fig 2.4 DC Motor

A DC motor is an electromechanical device that converts direct electrical energy into rotational mechanical motion. It typically operates within a voltage range of 6 V to 12 V in embedded and robotic applications, making it suitable for battery-powered systems. The motor consists of a rotor (armature) and a stator, and rotation is produced when current flowing through the armature interacts with the magnetic field generated by the stator[5]. The output characteristics of the motor are defined by its speed, measured in revolutions per minute (RPM), and torque, which represents the turning force available at the shaft. Shaft dimensions and gear ratios can vary depending on the application[1]. The rotational direction of the motor can be reversed by simply changing the polarity of the applied voltage, and the speed can be controlled using PWM signals from a motor driver such as the L298N. In this project, DC motors are used to drive the robot wheels, providing the necessary torque and controlled movement for field navigation[3].

5. SERVO MOTOR

Fig 2.5 Servo motor

A servo motor is a closed-loop actuator designed to provide precise control over angular position. It typically operates within a voltage range of 4.8 V to 6 V and receives control signals in the form of pulse-width modulation (PWM)[8][1]. The motor contains an internal feedback mechanism, usually a potentiometer, that continuously monitors the shaft position and adjusts the rotation to match the input command. Standard hobby servos offer a rotational range of approximately 0° to 180°, while high-torque variants can support heavier mechanical loads[8]. The compact structure, high positional accuracy, and low power consumption make servo motors suitable for automation and robotic applications requiring controlled motion. In this system, the servo motor is used to operate mechanical components that require precise angular movement, such as the seed dispensing mechanism[5].

6. WATER PUMP

Fig 2.5 Water pump

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The water pump used in the system is a compact 12-volt DC submersible pump designed for small-scale fluid transfer and irrigation applications[5]. It operates on low power and provides a steady water flow when submerged in a reservoir or tank. The pump contains a brushless motor, resulting in lower noise, minimal maintenance, and increased operational life compared to brushed equivalents. Its lightweight plastic housing ensures corrosion resistance and safe operation in outdoor or agricultural environments[4]. The pump is activated using a relay interface, allowing the microcontroller to switch it on or off based on user commands received via Bluetooth. Due to its moderate flow rate and energy efficiency, this pump is suitable for controlled irrigation tasks such as watering soil during sowing and supports continuous operation from the rechargeable battery and solar power system[1].

7. SOLAR PANEL

Fig 2.6 Solar panel

The solar panel used in the system serves as the primary renewable power source for charging the battery and supplying energy to the robot's electronics. It consists of multiple photovoltaic cells connected in series to produce a regulated DC output of approximately 12 volts, with a power rating typically between 3 W and 10 W depending on the application. The panel converts sunlight directly into electrical energy, enabling autonomous operation in outdoor agricultural environments without reliance on external power. Its durable construction, often with a tempered glass surface and aluminium frame, provides protection against moisture, dust, and mechanical stress. When integrated with a charge controller, the generated voltage is regulated to ensure safe charging of the rechargeable battery. The use of a solar panel makes the system energy-efficient, eco-friendly, and suitable for remote field conditions.

8. SOLAR CHARGE CONTROLLER

Fig 2.7 Solar charge controller

The solar charge controller is an essential power management unit that regulates the electrical energy supplied from the solar panel to the rechargeable battery[2]. Its main function is to monitor battery voltage and control the charging current to prevent overcharging, deep discharge, and reverse current flow, thereby enhancing battery life and system reliability. The controller typically operates with a 12-volt input from the solar panel and includes protection circuitry for overload and short-circuit conditions. Depending on the model, it may utilize PWM (Pulse Width Modulation) or MPPT (Maximum Power Point Tracking) technology[4]. PWM controllers maintain stable charging by adjusting the duty cycle of the input power, whereas MPPT controllers optimize energy harvesting by continuously tracking the panel's maximum power point. Visual indicators on the controller display charging and load status, enabling easy monitoring during field operation[5]. By ensuring safe and efficient energy transfer, the solar charge controller enables uninterrupted system operation in outdoor agricultural environments[8].

9. RECHARGEABLE BATTERY

Fig 2.8 Battery

The rechargeable battery serves as the primary energy storage component of the system, supplying power to the motors, controller, and auxiliary modules[5]. In this project, a 12-volt, 1.3-Ah battery is used, providing stable DC power that ensures continuous operation even in the absence of sunlight. The battery is designed to deliver a consistent discharge current, making it suitable for driving loads such as DC motors and water pumps. It supports multiple charge–discharge cycles and is compatible with solar charging through the charge controller. The sealed construction prevents leakage and allows the battery to operate safely in various environmental conditions[7]. Its compact size, high reliability, and ability to maintain voltage throughout the operating period make it suitable for mobile robotic applications where uninterrupted power supply is essential[8].

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Fig 2.9 Relay

The relay module is an electromechanical switching device used to control high-power loads using low-power logic signals from a microcontroller[5]. It operates on a 5-volt input from the control circuit and uses an internal electromagnetic coil to mechanically open or close the switch contacts. This electrical isolation allows sensitive electronics, such as the Arduino, to safely control devices that operate at higher voltages, including the water pump or external power supply lines[4]. The relay module typically includes an indicator LED that shows the switching status and a transistor driver to reduce the current required from the microcontroller pin. In this project, the relay enables the Arduino to activate and deactivate the water pump on command, providing safe and reliable load switching in the field environment[1].

S. I N O :-	Component:-	Function: -	Notes:-
1	Arduino Uno	Main controller ; reads sensors and controls motors	Works on 5V; supports digital, analog, UART, SPI, I2C
2	L298N Motor Driver	Drives two DC motors; controls speed & direction using PWM	High current up to 2A
3	HC-05 Bluetooth Module	Provides wireless mobile control	10m range
4	DC Motor	Used for robot wheel movemen t	Speed controlled using PWM
5	Servo Motor	Precise angular motion (0–180°)	Used for seed/controlled movement
6	Water Pump	Supplies water for irrigation	12V pump, relay-controlled
7	Solar Panel	Generates power from sunlight	≈12V output
8	Solar Charge Controller	Regulates solar charging	Prevents overcharge/discha rge
9	Rechargeable Battery	Stores energy for robot	12V, 1.3Ah
1 0	Relay Module	Switches high-pow er loads	Controls pump safely

10. RELAY MODULE

5. WORKING

The Smart Solar Powered Web-Controlled Multifunction Agribot is designed to perform various agricultural operations autonomously under the supervision of an Arduino Uno microcontroller[8][1]. The system draws its power from a solar panel, and the generated energy is stored in a rechargeable battery via a solar charge controller, ensuring uninterrupted functioning even in remote fields without grid access. The robot is controlled through a web-based interface, where user commands are transmitted to the onboard HC-05 Bluetooth module, which relays the input to the Arduino. Based on the received instruction, the controller activates the corresponding subsystem[1]. Locomotion is achieved using DC geared motors driven by the L298N motor driver module, enabling movements such as forward motion, reverse motion, and turning through differential wheel control.

For seed sowing, the Arduino operates a mechanical unit that opens the soil and dispenses seeds at defined intervals, ensuring uniform placement. When irrigation is selected, a relay triggers the DC water pump, allowing water to be supplied from an onboard tank through a nozzle. For grass trimming, a high-speed DC motor rotates a cutting blade to remove unwanted vegetation. The microcontroller ensures that each task is executed individually to manage power efficiently and avoid electrical overload[5]. By combining renewable energy utilization, wireless remote control, and multipurpose automation, the proposed agribot significantly reduces manual labour, enhances precision in field activities, and supports sustainable farming practices[3].

6. CODE IMPLEMENTATION

```
#include <SoftwareSerial.h> #include <Servo.h>

SoftwareSerial BT(10, 11); // RX, TX for Bluetooth module
Servo ploughServo;          // Servo motor for plough control

// Motor driver pins #define IN1 2

#define IN2 3
#define IN3 4
#define IN4 5
```

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```
#define SERVO_PIN 6          // Servo connected to pin 6
#define PUMP_PIN 7           // Water pump connected to
pin 7 (through relay or transistor)

char command;                // Variable to store Bluetooth
input bool pumpState = false;        // Track pump ON/OFF
state bool ploughDown = false;                  // Track plough
position

void setup() {
// Motor pins pinMode(IN1, OUTPUT); pinMode(IN2,
OUTPUT); pinMode(IN3, OUTPUT); pinMode(IN4,
OUTPUT);

// Pump control pin pinMode(PUMP_PIN, OUTPUT);
digitalWrite(PUMP_PIN, LOW); // Pump OFF initially

// Servo setup ploughServo.attach(SERVO_PIN);
ploughServo.write(90);  // Start in up position

// Bluetooth setup Serial.begin(9600); BT.begin(9600);

  Serial.println("Bluetooth Robot with Plough and
Water Pump Ready...");
}

void loop() {
if (BT.available()) { command = BT.read();
Serial.print("Command Received: ");
Serial.println(command);

switch (command) {
case 'F': moveForward(); break; case 'B': moveBackward();
break; case 'L': turnLeft(); break;
case 'R': turnRight(); break; case 'S': stopRobot(); break;
case 'U': ploughUp(); break;              // Servo plough up
case 'D': ploughDownFunc(); break; // Servo plough down
case 'W': pumpOn(); break;                // Water pump ON
case 'X': pumpOff(); break;              // Water pump OFF
default: stopRobot(); break;
}
}
}
```

```
// ---------- MOVEMENT FUNCTIONS ----------
void moveForward() { digitalWrite(IN1, HIGH);
  digitalWrite(IN2, LOW); digitalWrite(IN3, HIGH);
  digitalWrite(IN4, LOW);
  }

void moveBackward() { digitalWrite(IN1, LOW);
  digitalWrite(IN2, HIGH); digitalWrite(IN3, LOW);
  digitalWrite(IN4, HIGH);
  }
void turnLeft() { digitalWrite(IN1, LOW); digitalWrite(IN2,
  HIGH); digitalWrite(IN3, HIGH); digitalWrite(IN4, LOW);
  }

void turnRight() { digitalWrite(IN1, HIGH); digitalWrite(IN2,
  LOW); digitalWrite(IN3, LOW); digitalWrite(IN4, HIGH);
  }

void stopRobot() { digitalWrite(IN1, LOW); digitalWrite(IN2,
  LOW);

 digitalWrite(IN3, LOW); digitalWrite(IN4, LOW);
 }


 // ---------- PLOUGH CONTROL ----------
 void ploughUp() {
 ploughServo.write(90); // Move to up position
 Serial.println("Plough Up");
 }
void ploughDownFunc() {  ploughServo.write(30); // Move to
 down position Serial.println("Plough Down");
 }
 // ---------- WATER PUMP CONTROL ----------
void pumpOn() { digitalWrite(PUMP_PIN, HIGH);
 Serial.println("Water Pump ON");
 }
void pumpOff() { digitalWrite(PUMP_PIN, LOW);
 Serial.println("Water Pump OFF");

 }
```

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8.APP AND TERMINAL

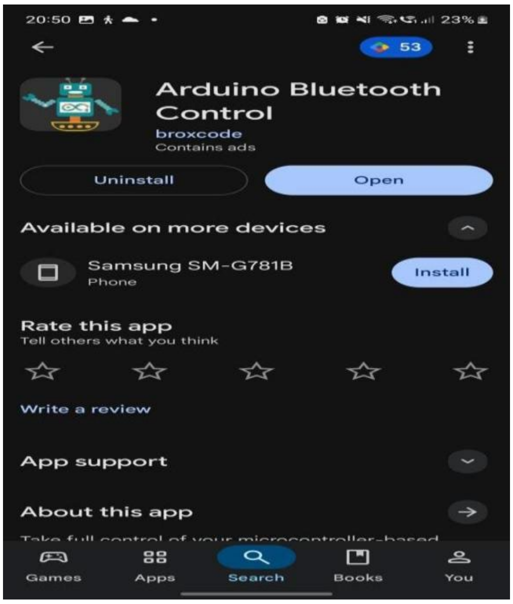

Fig 3.1 APP

The above fig is the app based platform where the robot is controlled using this this platform source.

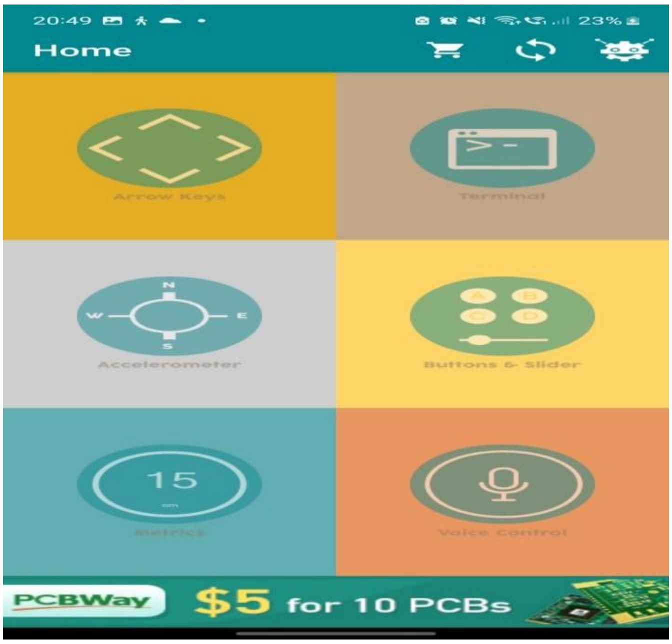

Fig 3.2 Terminal

The above fig is a photo pic of app terminal where controlling is happened.

9. PROTOTYPE MODEL

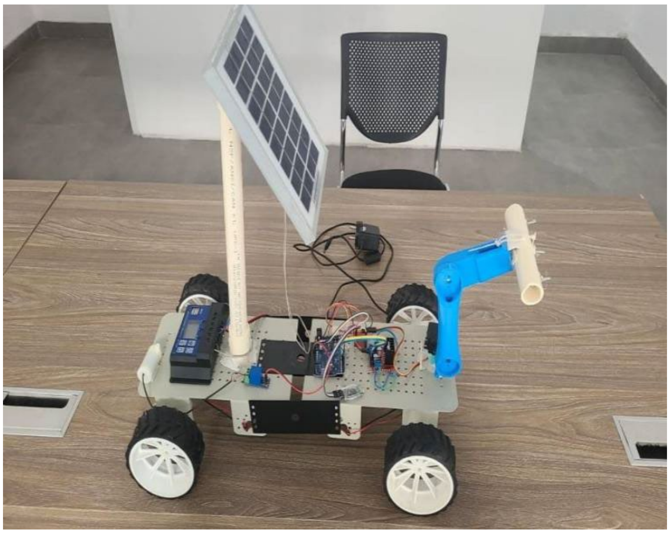

Fig 4.1 Agribot model

The above figure contains solar panel,battery,servo motors,HC-05 bluetooth , ploughing,watering followered by,wheels and rod ,etc.

9. RESULT

The developed Smart Solar Powered Web Controlled Multi-Function Agribot was successfully designed, assembled, and tested in real agricultural field conditions[3]. The robot responded accurately to user commands transmitted through the mobile/web interface, enabling smooth movement in forward, reverse, left, and right directions[6][5]. Each individual function seeding, watering, and grass cutting was executed reliably under Arduino-based control. The seeding mechanism consistently dropped seeds into the soil with uniform spacing, demonstrating repeatable accuracy without clogging or misalignment. The irrigation module, powered by a DC pump and activated through a relay, delivered controlled water flow, allowing users to irrigate only the targeted area and reducing water wastage compared to manual watering. The grass-cutting unit performed effective trimming of small weeds and unwanted vegetation, keeping the test plot clean[8].

The integration of a solar panel and charge controller ensured that the onboard rechargeable battery remained charged during outdoor testing[4]. The robot operated continuously for several hours under sunlight without requiring external charging, validating the feasibility of renewable energy for agricultural automation[2]. Communication through Bluetooth or web control remained stable within an effective range, allowing users to operate the robot remotely without physical interaction. Overall, the system demonstrated reduced labour effort, improved operational efficiency, and sustainable energy utilization, confirming that the robot is a practical and cost-effective solution for small and medium scale farms[5].

10. CONCLUSION

The Smart Solar Powered Web Controlled Multifunction Agribot successfully demonstrates an efficient and sustainable approach to automating essential farming operations[1]. By integrating multiple functions such as seed sowing, watering, and grass cutting into a single robotic platform, the system reduces manual labour and improves the precision of field activities[8]. The use of solar energy as the primary power source minimizes operational costs and enables deployment in remote agricultural areas where electricity is not readily available[5]. Web based remote control enhances usability and gives farmers the ability to operate the robot from a distance, promoting safety and convenience[2]. The experimental results validate that the proposed system is effective for small and medium scale agricultural applications[8]. Future enhancements may include GPS based autonomous navigation, IoT-based monitoring, and the integration of advanced sensors for real-time field analysis[7].Overall, this work contributes toward the development of smart and sustainable farming practices by combining automation, renewable energy, and modern communication technologies[2].

11. FUTURE SCOPE

The Smart Solar Powered Web Controlled Multifunction Agribot has significant potential for future enhancement and adaptation to advanced agricultural needs[2]. Integrating artificial intelligence and computer vision can enable intelligent functionalities such as automatic weed detection, obstacle avoidance, and real-time crop health monitoring. The addition of GPS based navigation can further support autonomous movement and optimized path planning for large-scale agricultural fields[3]. Improvements in power management and battery optimization can extend the robot's operating duration, ensuring reliable performance even during low sunlight conditions[6]. The modular design of the system also allows the inclusion of additional attachments for pesticide spraying, soil nutrient analysis, and crop growth monitoring. With further development involving sensor fusion and AI-based decision-making, the robot can evolve into a fully autonomous and self-operating platform that requires minimal human intervention[8]. These advancements would make the system a scalable and intelligent solution for precision agriculture and sustainable farming practices[9].

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utomation;Agribot;Arduino;solar
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