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AUTOMATIC FERTILIZER SPRAYING ROBOT

Ch.Shanker Sharma, D.Rakesh, Dr. P. V.N. Reddy, U.Venu, Irfana
Department Of Electronics and Communication Engineering Vaagdevi College Of Engineering
Warangal, India

Abstract—The agriculture industry is highly resource- and labor-intensive. Therefore, farmers are increasingly turning to technology and automation to address these challenges. However, existing agricultural robots are often complex, slow, and expensive, hindering widespread adoption. Consequently, the agriculture sector still lags behind in integrating modern technologies. Our project focuses on developing a low-cost agricultural robot for spraying fertilizers and pesticides in agriculture fields, as well as for general crop monitoring. The prototype system comprises a two-wheeled robot with a mobile base, a spraying mechanism, and a wireless controller for robot movement. The prototype system demonstrates that while the robot's productivity in terms of crop coverage is slightly lower than that of a human worker, the labor cost savings offered by the agricultural robot prototype are substantial. This is due to its ability to operate autonomously, requiring human intervention only for initial placement at the start of the crop path.

Keywords—Agriculture, Industry, Technology, Pesticides, Fertilizers

I. INTRODUCTION

OVERVIEW OF AUTOMATIC FERTILIZER SPRAYING ROBOT

An automatic fertilizer spraying robot is an agricultural robot designed to spray fertilizers on crops automatically. It is an advanced technology used in modern farming to enhance crop productivity and reduce labor costs. Equipped with sensors and advanced control systems, the robot navigates through the farm and accurately sprays fertilizers. It can be remotely controlled via a smartphone or computer, enabling farmers to monitor crop growth and adjust spraying as needed. Powered by rechargeable batteries, the robot can operate for long hours without human intervention, with some models even being solar-powered to reduce the need for battery recharging. The use of such robots reduces manual labor, thereby decreasing the need for human workers in the field and improving economic efficiency. Additionally, it minimizes adverse effects associated with manual fertilizer spraying, such as chemical exposure and respiratory issues. Environmentally friendly, the robot promotes proper fertilizer use, thereby reducing ecosystem damage. Maintenance is relatively straightforward, with most tasks manageable by farmers with minimal training.

CURRENT WORK

These robots aim to precisely and efficiently apply fertilizers to crops, optimizing nutrient distribution and reducing waste. However, specific details on the latest advancements or ongoing projects beyond the indicated date are unavailable due to the lack of real-time information. Typically, automatic fertilizer spraying robots utilize GPS and sensor systems to navigate fields and determine optimal locations for fertilizer application.

II. LITERATURE REVIEW AND PROBLEM INTERFACING

LITERATURE REVIEW: SMART FARMING USING AGRI-BOT

In a paper by K. Gowthami, K. Greeshma, and N. Supraja (IJAER, 2019), a system is proposed for performing seeding tasks in agricultural fields without human intervention. The development aims to implement a prototype of an effective low-cost agribot, leveraging wireless communication through Arduino and Bluetooth.

IOT BASED SMART AGRICULTURE TOWARDS MAKING FIELD TASKS EASIER

Muhammad Ayaz, Mohammad Ammad-uddin, Zubair Sharif, Ali Mansour, and M. Aggoune (IEEE, 2019) proposed a multitasking IoT-based technology for agriculture, aiming to meet the rising food demand with minimal human interaction. This approach utilizes wireless sensors, UAVs, cloud computing, and communication technologies for comprehensive farming from planting to harvesting.

AGRICULTURE AUTOMATION SYSTEM WITH FIELD ASSISTING ROBOT

In a study by Archit Keshav Gangal and Farheen (IJPAM, 2018), an Arduino UNO-powered system is developed with functions for plowing, seed dispensing, and harvesting. The system employs a camera to detect obstacles and take necessary actions, aiming to reduce labor hours, expenses, and ensure precise seeding.

IOT ENABLED FERTILIZER SPRAYER WITH SECURITY SYSTEM BY USING SOLAR ENERGY

Amaresh. A.M., Anagha G Rao, Fennaz Afreen, and Moditha.N (IJERT, 2020) introduced an agricultural robot controlled via an Android application, designed for pesticide spraying using a solar-powered pumping system.

SOLAR POWERED AGRIROBOT FOR FARMING USING IOT

Sivaprasad Athikkal, Ambarish Pradhan, Abhilash Gade, and A. Mahidhar Reddy (IJEET, 2020) proposed an Agribot equipped with IR, moisture, and temperature sensors, powered by solar panels. The robot irrigates the land based on soil temperature, sending data to the cloud and adjusting its path to avoid obstacles, with the aim of providing an economical solution for farmers.

THEORETICAL BACKGROUND OF IOT

The Internet of Things (IoT) plays a vital role in daily life, industry, and society. By 2020, the number of connected devices is expected to exceed 50 billion, including a quarter billion vehicles connected to the internet. IoT's impact extends to the economy, with estimates of trillions generated in both public and private sectors over the next decade. Automation, exploration, and various applications are being developed, facilitated by IoT. The IEEE Society of Robotics and Automation's Technical Committee on Networked Robots defines two subclasses of networked robots: tele-operated robots, where human supervisors send commands and receive feedback via the network, and autonomous robots, where robots and sensors exchange data with minimal human intervention, coordinating their activities and extending effective sensing range through sensor networks.

EXISTING METHOD

Fig. 1. BLOCK DIAGRAM OF EXISTING METHOD

DESCRIPTION OF EXISTING METHOD

Pesticide spraying and fertilizer scattering are laborious tasks in agriculture. Despite being necessary, pesticide spraying is often considered hazardous by farmers. This project focuses on developing an agricultural robot vehicle controlled via an Android application based on the farmer's instructions. The vehicle utilizes cost-effective components, enhancing its affordability. Farmers can control the robot using any Android smartphone equipped with the corresponding application. Through an IoT application, farmers can manage pesticide spraying devices, improving efficiency, safety, and addressing labor demands in agricultural settings.

The Android application facilitates the control of the spraying rover. Initially, it establishes a connection with the HC05 Bluetooth module to oversee all hardware components of the rover. Once connected, the spraying rover can be easily controlled. The rover is equipped with four brushless DC motors controlled by an L293D motor driver. These motors receive power from a 12V battery and are manipulated through the motor driver. Additionally, servo motors are utilized to control the sprayer part of the rover. These motors precisely adjust the position of the sprayer as per user requirements. The Arduino Uno board receives commands from the Android application and orchestrates the rover's operations.

Furthermore, the system incorporates a 6V pump, which is connected to the Arduino and passes through a buck converter and relay module to control the high-voltage pump. A relay module acts as a switch, regulated electrically by an electromagnet. It uses a low voltage to activate the electromagnet, controlling a high voltage circuit. Due to the high voltage requirement of the 12V battery, a buck converter is employed to step down the voltage to a safer level. The operation of the circuit is governed by the conduction state of the MOSFETs.

Additionally, temperature and humidity sensors are integrated into the rover to predict weather conditions before pesticide spraying.

APPLICATIONS

• Identification of crop conditions and corresponding chemical application, spraying, or harvesting as required by the crop.

• Mobile manipulation through collaborative arms for harvesting and fruit handling.

• Collection and analysis of useful information for farmers.

• Selective application of pesticides to minimize waste.

ADVANTAGES

• Reduced direct exposure to pesticides, enhancing human safety and production efficiency.

• Operation with closer tolerances, fewer errors, and higher speeds, leading to reliable detection of high-quality goods.

• Potential to reduce up to 30% of pesticide usage.

• Potential to create jobs for individuals involved in building and repairing robots.

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III. METHODOLOGY

DESCRIPTION OF AUTOMATIC FERTILIZER SPRAYING ROBOT

We developed an Android application to control the spraying robot. Initially, the application establishes a connection with the ESP32 Wi-Fi module to manage all hardware components of the spraying robot. Once connected to Wi-Fi, the spraying robot can be easily controlled. The robot is equipped with two DC gear motors controlled by an L298N motor driver. These motors receive power from a 12V battery and are manipulated through the motor driver. Additionally, a 6V water pump is utilized, connected to the motor driver and passing through a buck converter. A buck converter regulates the voltage to ensure safe operation.

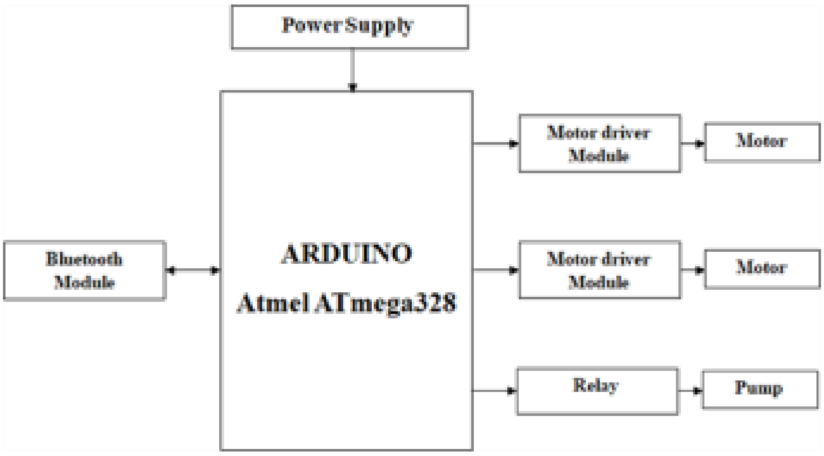
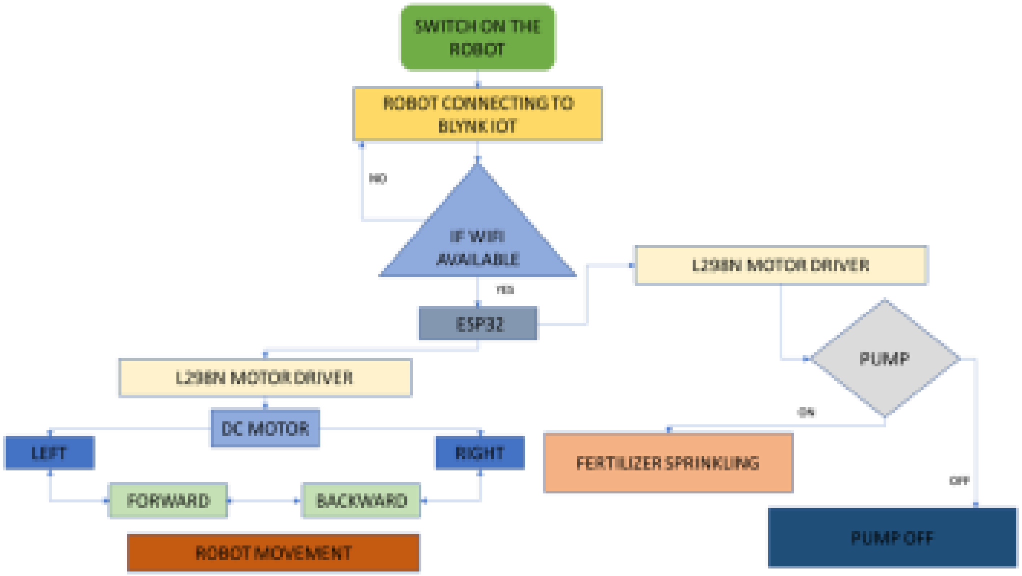


Fig. 2. BLOCK DIAGRAM OF AUTOMATIC FERTILIZER ROBOT

HARDWARE SETUP

1. Connect the ESP32 to two L298N Motor Drivers.
2. Connect DC gear motors and three Li-ion batteries to one of the L298N Motor Drivers.
3. Connect water pumps to another L298N Motor Driver.
4. Connect water pipes to water pumps.
5. Connect two Li-ion batteries to the other L298N Motor Driver.
6. Connect the Solar Panel to ESP32 and Li-ion batteries using jumper wires.
7. Ensure all connections are secure and properly seated.
8. Double-check the wiring to prevent potential electrical issues.



SOFTWARE SETUP

1. Download and install the Arduino IDE on your computer.
2. Launch the Arduino IDE and go to the "Preferences" window.
3. Enter the URL for the ESP32 boards package in the "Additional Board Manager URLs" field.
4. Open the Boards Manager from the "Tools" menu, search for "esp32," and install the package.
5. Select the appropriate ESP32 board from the "Tools" -> "Board" menu.
6. Install the required libraries by going to "Sketch" -> "Include Library" -> "Manage Libraries" and searching for the necessary libraries.
7. Import the project code into the Arduino IDE.
8. Connect the ESP32 to your computer using a USB cable.
9. Select the correct port from the "Tools" -> "Port" menu in the Arduino IDE.
10. Click on the "Upload" button to compile and upload the code to the ESP32.
11. Wait for the code to upload successfully.

CONNECTING WITH THE BLYNK IOT APP

1. Download and install the BLYNK IOT app on your mobile device.
2. Open the app and create a quick start device window.

3. Turn on your mobile hotspot and keep the username as "robot" and the hotspot password as "12345678," then search for available devices.
4. Select the ESP32 from the list of devices.
5. Once connected, control the robot through the app.
6. Test the connectivity and functionality by sending commands to the ESP32.

RUNNING THE AUTOMATIC FERTILIZER SPRAYING ROBOT

1. Connect the power supply to the ESP32 and ensure it has a stable power source.
2. Launch the BLYNK IOT app on your mobile device.
3. Check the connectivity with the ESP32 and ensure it is successfully connected.
4. Send commands to the ESP32 via the app.
5. The ESP32 will send commands to both motor drivers.
6. Move the robot and spray the fertilizer.

IV. IMPLEMENTATION HARDWARE DESCRIPTION

ESP32

Fig. 3. ESP32

HIGH LEVEL OF INTEGRATION

The ESP32 is highly integrated with built-in antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power management modules. It adds valuable functionality and versatility to applications with minimal PCB requirements.

ULTRA LOW POWER CONSUMPTION

The ESP32 features ultra-low power consumption, making it suitable for battery-powered applications.

HYBRID WI-FI AND BLUETOOTH CHIP

The ESP32 can function as a standalone system or as a slave device to a host MCU, reducing communication stack overhead. It interfaces with other systems to provide Wi-Fi and Bluetooth functionality through SPI/SDIO or I2C/UART interfaces.

ROBUST DESIGN

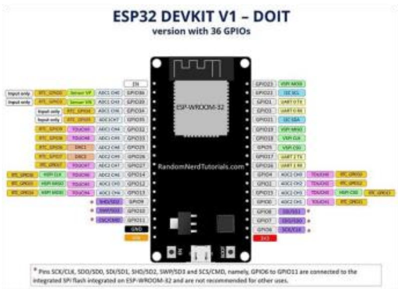
The ESP32 operates reliably in industrial environments, with an operating temperature range from -40°C to +125°C. Powered by advanced calibration circuitries, it can adapt to changes in external conditions.

INTRODUCTION OF ESP32

The ESP32 is a powerful microcontroller developed by Espressif Systems, serving as the successor to the ESP8266. It features dual-core processing, Wi-Fi, Bluetooth, and BLE connectivity, making it suitable for IoT applications. Built on the Tensilica Xtensa LX6 microarchitecture, it operates at up to 240 MHz with 520KB RAM and 4MB Flash memory. It supports multiple low-power modes and can be programmed using C/C++, MicroPython, or Arduino IDE.

TYPES OF ESP

Various types of ESP boards are available, including ESP8266, ESP32, ESP32-S2, ESP32-CAM, ESP8266 NodeMCU, and ESP32 WROOM. Each type caters to different application requirements and development preferences.



SPECIFICATIONS

- Dual-core processor
- Built-in Wi-Fi and Bluetooth
- Clock frequency up to 240MHz
- 512KB RAM
- 4MB Flash memory
- GPIO pins for interfacing with peripherals

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- Wide operating voltage range of 2.2V to 3.6V

L298N MOTOR DRIVER

The L298N Motor Driver module facilitates the control of two DC motors or one bipolar stepper motor. It operates with a voltage range of 5 to 35V DC and includes an onboard 5V regulator. The module provides speed and direction control for motors, with speed controlled via ENA and ENB pins and direction controlled via IN1, IN2, IN3, and IN4 pins.

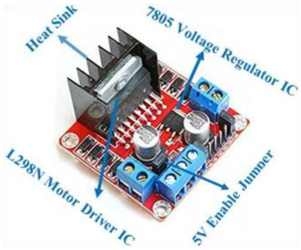

Fig. 5. L298N MOTOR DRIVER

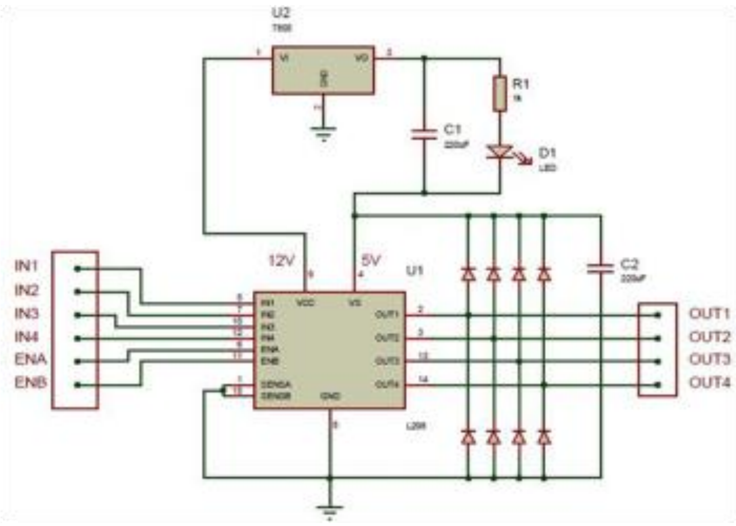

Fig. 6. CIRCUIT DIAGRAM OF L298N MOTOR DRIVER

Connect the power supply to the motors. In the robot, we are using DC Gearbox Motors that are usually found in two-wheel-drive robots. They are rated for 3 to 12V. So, we will connect an external 12V power supply to the VCC terminal. Considering the internal voltage drop of the L298N IC, the motors will receive 10V and will spin at slightly lower RPM.

We need to supply 5 Volts for the L298N's logic circuitry. We will make use of the onboard 5V regulator and derive the 5 volts from the motor power supply, so keep the 5VEN jumper in place. Now, the input and enable pins (ENA, IN1, IN2, IN3, IN4, and ENB) of the L298N module are connected to six Arduino digital output pins

(9, 8, 7, 5, 4, and 3). Note that the Arduino output pins 9 and 3 are both PWM-enabled. Finally, connect one motor to terminal A (OUT1 & OUT2) and the other motor to terminal B.

HISTORY OF L298N MOTOR DRIVER

The L298N is a popular dual H-bridge motor driver integrated circuit (IC) that provides a convenient way to control and drive DC motors and stepper motors. It has been widely used in robotics, automation, and other projects that require motor control.

Despite the availability of newer options, the L298N motor driver remains widely used and continues to be an accessible and reliable choice for motor control applications. Its robustness, versatility, and extensive documentation have contributed to its enduring popularity.

FEATURES AND SPECIFICATIONS:

- Driver Model: L298N 2A
- Driver Chip: Double H Bridge L298N
- Motor Supply Voltage (Maximum): 46V
- Motor Supply Current (Maximum): 2A
- Logic Voltage: 5V
- Driver Voltage: 5-35V
- Driver Current: 2A
- Logical Current: 0-36mA
- Maximum Power (W): 25W
- Current Sense for each motor
- Heatsink for better performance
- Power-On LED indicator

PIN DESCRIPTION:

1. DC motor 1 ”+” or stepper motor A+
2. DC motor 1 ”-” or stepper motor A-
3. 12V jumper - remove this if using a supply voltage greater than 12V DC. This enables power to the onboard 5V regulator
4. Connect your motor supply voltage here, maximum of 35V DC. Remove 12V jumper if ¿12V DC

5. GND
6. 5V output if 12V jumper in place, ideal for powering your Arduino.
7. DC motor 1 enable jumper. Leave this in place when using a stepper motor. Connect to PWM output for DC motor speed control.
8. IN1
9. IN2
10. IN3
11. IN4
12. DC motor 2 enable jumper. Leave this in place when using a stepper motor. Connect to PWM output for DC motor speed control.
13. DC motor 2 ”+” or stepper motor B+
14. DC motor 2 ”-” or stepper motor B-

DC GEAR MOTORS

To control one or two DC motors is quite easy. First connect each motor to the A and B connections on the L298N module. If you’re using two motors for a robot (etc), ensure that the polarity of the motors is the same on both inputs. Otherwise, you may need to swap them over when you set both motors to forward and one goes backwards! Next, connect your power supply - the positive to pin 4 on the module and negative/GND to pin 5. If your supply is up to 12V you can leave in the 12V jumper (point 3 in the image above) and 5V will be available from pin 6 on the module. This can be fed to your Arduino’s 5V pin to power it from the motors’ power supply. Don’t forget to connect Arduino GND to pin 5 on the module as well to complete the circuit. Now you will need six digital output pins on your Arduino, two of which need to be PWM (pulse-width modulation) pins. PWM pins are denoted by the tilde ("~") next to the pin number, for example: Finally, connect the Arduino digital output pins to the driver module. In our example, we have two DC motors, so digital pins D9, D8, D7, and D6 will be connected to pins IN1, IN2, IN3, and IN4 respectively. Then connect D10 to module pin 7 (remove the jumper first) and D5 to module pin 12 (again, remove the jumper).

INTRODUCTION TO DC GEAR MOTOR

A DC motor is any of a class of rotary electrical machines that converts direct current electrical energy into mechanical energy. The most common types rely on the forces produced by magnetic fields. Nearly all types of DC motors have some internal mechanism, either electromechanical or electronic, to periodically change the direction of current flow in part of the motor.

Fig. 7. DC GEAR MOTOR

BRUSHED DC MOTOR

The brushed DC electric motor generates torque directly from DC power supplied to the motor by using internal commutation, stationary magnets (permanent or electromagnets), and rotating electrical magnets. Advantages of a brushed DC motor include low initial cost, high reliability, and simple control of motor speed. Disadvantages are high maintenance and low life-span for high-intensity uses. Maintenance involves regularly replacing the carbon brushes and springs which carry the electric current, as well as cleaning or replacing the commutator. These components are necessary for transferring electrical power from outside the motor to the spinning wire windings of the rotor inside the motor. Brushes consist of conductors.

BRUSHLESS DC MOTOR

Typical brushless DC motors use one or more permanent magnets in the rotor and electromagnets on the motor housing for the stator. A motor controller converts DC to AC. This design is mechanically simpler than that of brushed motors because it eliminates the complication of transferring power from outside the motor to the spinning rotor. The motor controller can sense the rotor's position via Hall effect sensors or similar devices and can precisely control the timing, phase, etc., of the current in the rotor coils to optimize torque, conserve power, regulate speed, and even apply some braking. Advantages of brushless motors include long life span, little or no maintenance, and high efficiency. Disadvantages include high initial cost and more complicated motor speed controllers. Some such brushless motors are sometimes referred to as "synchronous motors" although they have no external power supply to be synchronized with, as would be the case with normal AC synchronous motors.

SERIES CONNECTION

A series DC motor connects the armature and field windings in series with a common D.C. power source. The motor speed varies as a non-linear function of load torque and armature current; current is common to both the stator and rotor yielding current squared behavior. A series motor has very high starting torque and is commonly used for starting high inertia loads, such as trains, elevators, or hoists. Speed control is achieved by varying the voltage applied to the motor. This is often done using a variable resistance in series with the motor, but may also be done with a series-wound motor controller. Series motors are used where a compact and lightweight motor with high starting torque is needed.

PARALLEL CONNECTION

A shunt DC motor connects the armature and field windings in parallel or shunt with a common D.C. power source. This type of motor has good speed regulation even as the load varies, but does not have the starting torque of a series DC motor. It uses the same principle of the electromagnet but doesn't have the same mechanism. As the rotor turns, the brushes come in contact with the commutator and change the magnetic polarity, which keeps the rotor spinning. Shunt wound motors are used in applications where the speed regulation is important but not the starting torque. Such applications include elevators, conveyors, and industrial plants.

V. RESULT ANALYSIS

An automatic fertilizer spraying robot is a specialized robot designed to autonomously apply fertilizers to plants or crops in agricultural settings. It incorporates various technologies and components to efficiently and accurately distribute the required amount of fertilizer over a designated area. Overall, automatic fertilizer spraying robots aim to streamline and optimize the fertilization process.

MOBILITY: The robot is equipped with wheels or tracks, allowing it to move across different terrains and navigate through crop rows or fields. Some advanced models may even have the ability to fly or hover using drones for more flexible coverage.

SENSORS AND MAPPING: The robot is equipped with sensors, such as GPS, LiDAR, or cameras, to gather data about the environment and create a digital map of the area to be fertilized. This information helps the robot navigate and avoid obstacles while ensuring complete coverage.

FERTILIZER STORAGE AND DISTRIBUTION: The robot carries a reservoir or tank to store the liquid or granular fertilizer. It is designed to safely hold and dispense the fertilizer during the spraying process. The amount of fertilizer dispensed can be controlled to ensure the right dosage for each area.

SPRAYING MECHANISM: The robot utilizes a spraying mechanism, such as nozzles or sprayers, to evenly distribute the fertilizer over the plants or soil. The spraying system can be adjustable to adapt to different crop heights and density.

PRECISION CONTROL: The robot is typically equipped with advanced control systems that enable precise application of fertilizers. This may include features like variable rate application, where the amount of fertilizer sprayed is adjusted based on real-time data or specific requirements for each area.

AUTONOMOUS OPERATION: The robot operates autonomously using pre-programmed instructions or artificial intelligence algorithms. It can follow predefined routes, make adjustments based on the mapped environment, and respond to changing conditions or obstacles encountered during the operation.

CONNECTIVITY AND DATA ANALYSIS: Some models may have connectivity features that allow them to communicate with a central system or farm management software. This enables remote monitoring, data collection, and analysis of the fertilization process, optimizing resource usage and decision-making.

SAFETY FEATURES: To ensure safe operation, the robot may be equipped with sensors and mechanisms to detect and avoid obstacles, including humans or animals, during its movement. Emergency stop buttons and fail-safe systems further enhance safety.

VI. CONCLUSION AND FUTURE SCOPE

CONCLUSION: The hardware components have been successfully assembled, and the robot has been able to communicate with the ESP32. The ability to control the robot’s motion through Wi-Fi and an Android applet has been achieved. As a result, the two control modules for the robot have been successfully tested and demonstrated. While controlling a robot with Bluetooth limits the range of communication distance, it is a smart and simple way to direct a robot. One of the simplest ways to control the motion of a robot is to use the internet. Since it necessitates the user’s access to the specified guide. People would find it easy to use. In comparison to another unit, this is less expensive.

Furthermore, automatic fertilizer spraying robots enable the collection of valuable data on soil conditions, plant health, and nutrient requirements. This data can be analyzed to make informed decisions, leading to optimized fertilization strategies and improved overall crop management. With their versatility, these robots can be utilized in various agricultural settings, such as fields, greenhouses, or indoor farming systems, and can be adapted to different crops and growth stages. Overall, automatic fertilizer spraying robots provide an innovative and sustainable solution for precise and efficient fertilizer application, contributing to enhanced productivity, reduced environmental impact, and improved profitability in modern agriculture.

FUTURE SCOPE: The future scope of automatic fertilizer spraying robots is promising, with several potential developments and advancements expected in the coming years. Some of the key areas of future growth and exploration include:

ADVANCED SENSING TECHNOLOGIES: The incorporation of advanced sensing technologies, such as hyperspectral imaging, drones, and satellite imagery, can enhance the capabilities of fertilizer spraying robots. These sensors can provide real-time data on plant health, nutrient deficiencies, and soil conditions, allowing the robots to adjust fertilizer application strategies on the fly.

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING: Integration of artificial intelligence (AI) and machine learning algorithms can enable robots to learn from data collected over time. This would allow them to make autonomous decisions regarding fertilizer application, optimizing the process based on historical and real-time information.

MULTI-TASKING CAPABILITIES: Future fertilizer spraying robots may be designed to perform multiple tasks simultaneously. For example, they could combine weed detection and removal functionalities, allowing for integrated weed control along with fertilizer application. This would further reduce the need for separate operations and improve overall efficiency.

SWARM ROBOTICS: Swarm robotics involves the coordination and collaboration of multiple robots working together to accomplish tasks. Future developments may include the use of multiple smaller robots that can communicate and operate as a cohesive unit. This approach could enhance coverage, speed, and efficiency in fertilizer application across large areas.

AUTONOMOUS NAVIGATION AND MAPPING: Improved autonomous navigation capabilities would enable robots to navigate complex terrains, avoiding obstacles and optimizing their routes.

INTEGRATION WITH FARM MANAGEMENT SYSTEM: Automatic fertilizer spraying robots can be integrated with farm management systems, allowing for seamless data exchange and coordination with other agricultural processes. This integration would enable farmers to have a holistic view of their operations, optimizing fertilizer application based on real-time data, weather conditions, and crop requirements.

ENERGY EFFICIENCY AND SUSTAINABILITY: Future advancements in battery technology and energy management systems can enhance the energy efficiency of fertilizer spraying robots. Additionally, the development of eco-friendly fertilizers and nutrient delivery systems can further contribute to sustainable agricultural practices.

CUSTOMIZATION FOR SPECIFIC CROPS AND REGIONS: As agricultural practices vary across different crops and regions, there is potential for the customization of fertilizer spraying robots to cater to specific needs. This may include the development of specialized attachments, nozzle configurations, or algorithms optimized for specific crop types or geographical conditions.

In summary, the future scope of automatic fertilizer spraying robots lies in the integration of advanced sensing technologies, AI and machine learning, multi-tasking capabilities, swarm robotics, autonomous navigation and mapping, integration with farm management systems, energy efficiency, and customization. These advancements have the potential to revolutionize the way fertilizers are applied in agriculture, leading to increased efficiency, improved resource management, and sustainable farming practices.

APPLICATIONS:

- Field Crop Farming
- Orchard and Vineyard Management
- Controlled Environment Agriculture (CEA)
- Precision Agriculture
- Research and Development
- Integration with Farm Management Systems
- Organic Farming

These applications demonstrate the versatility and potential impact of automatic fertilizer spraying robots across various agricultural sectors, contributing to enhanced productivity, sustainability, and profitability.

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