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Multi-Purpose Agriculture Robot for Autonomous Seeding and Pesticide Spraying

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Abstract: *By increasing productivity and sustainability, an autonomous agricultural robot for sowing and pesticide application transforms farming methods. Making use of advanced The robot uses robotics and intelligent sensors to carry out two essential farming activities on its own. Its precision seeding system maximizes crop yields and minimizes waste by guaranteeing precise planting depths and spacing In the meantime, smart sensors reduce chemical use and environmental effect by enabling targeted pesticide spraying and monitoring the presence of pests and plant health. This robot promotes sustainable agriculture practices while streamlining farming procedures and saving time and resources through automated operations. These developments open the door to more intelligent, environmentally responsible and technologically advanced faming solutions*

Keywords: Robotic seeding, precision farming, pesticide spraying, autonomous agriculture, and smart farming

I. INTRODUCTION

A vital sector of the economy, agriculture faces issues such a lack of workers, wasteful use of resources, and environmental problems. Conventional methods of sowing and applying pesticides Techniques are time-consuming and frequently result in waste, unequal distribution, and overuse of chemicals, which have a detrimental effect on crop yields and the environment [1]. Precision agriculture is increasingly using automation and robotics to address these problems [2]. Modern farming has showed great promise for increasing sustainability and efficiency through the combination of robotics, artificial intelligence (AI), and the Internet of Things (IoT) [3]. By guaranteeing accurate seed placement and targeted pesticide application, autonomous agricultural robots can streamline crucial farming tasks and cut down on manual labor and resource waste [4]. This study describes the creation of a multi functional agricultural robot intended for Automatic spraying of pesticides and seeding. To do these duties properly, the system makes use of smart sensors, robots, and machine learning. The robot uses GPS, real-time environmental monitoring, and AI-based decision-making to ensure optimal seed dispersal, reduce excessive use of pesticides, and function independently. This study supports sustainable agriculture by increasing productivity while lowering costs for operation and environmental effect through the use of smart technologies.

II. LITERATURE REVIEW AND OBJECTIVES

A. LITERATURE REVIEW

Several studies have looked into using robotic devices to automate pesticide spraying. Key contributions in this field are reviewed in this section.

AGROBOT for Leaf Disease Diagnosis and Pesticide Spraying An automated agricultural robot (AGROBOT) was proposed by Sumithra and Gayathiri [1] with the purpose of precisely spraying pesticides and detecting diseases early.

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In real-world simulations, the system proved to be dependable, precise, and effective, improving performance and lowering pesticide abuse. Gengaje and Deshmukh, ARM-Based Robots for Spraying Pesticides.[2] developed an ARM LPC2148-based robotic pesticide application system. To determine the affected areas, crop images captured by a wireless camera are analyzed at a central station. In order to reduce manual labor and pesticide abuse, the robot then sprays pesticides under human supervision. Development and Management of a Spraying Robot Raval and colleagues. revealed an autonomous spraying robot that uses visual processing to identify plant problems. After analyzing the images to identify infections, the equipment evidently sprays pesticides on the affected spots. This strategy minimizes human exposure to dangerous chemicals while optimizing the usage of pesticides. Autonomous Pesticide Spraying in Greenhouses, Sammons et al.[4] suggested an autonomous spraying robot designed specifically for greenhouses. The machine navigates the greenhouse and evenly applies pesticides using induction proximity sensors. The findings indicated that the robot complied with agricultural requirements while guaranteeing effective distribution of pesticides. Intelligent Management in Simulated Pesticide Spraying A smart control simulation for pesticide spraying was created by Chengzhi et al. [5]. The technology offers flexibility for a range of agricultural environments by combining wireless networks with modular designs for effective and flexible pesticide delivery. Overview and Research Deficits Even though the current research makes great strides, there are still issues to be resolved, like increasing crop variety adaptability, boosting real-time decision-making, and combining IoT and AI for increased efficiency. For large-scale agricultural applications, future research should concentrate on improving autonomous decision-making and real-time data processing.

B. OBJECTIVES

The following are this project's main goals:

1) Design and Development : To create a multi functional agricultural robot that can carry out duties like pesticide spraying and seeding on its own .

2) Sensor Integration: The implementation of advanced sensors and navigation systems for accurate functioning in a range of field circumstances is known as sensor integration.

3) Algorithm Development :Using real-time data, algorithms are developed for effective task scheduling and decision-making.

4) Performance Evaluation: To assess how well the robot performs in agricultural applications in terms of accuracy, speed, and effectiveness.

5) Sustainable Farming : To minimize the use of chemicals and maximize resource management in order to promote sustainable farming methods.

III. MATERIALS AND METHODS

A. RESOURCES

A variety of hardware and software components are needed for sensing, navigation, and actuation in the creation of the multipurpose agricultural robot.

1) Raspberry Pi 3b+

One little board computer is the Raspberry Pi 3B+. It can perform some tasks similar to those of a standard com-puter and features a CPU, GPU, USP ports and I/O pins, Wi-Fi, Bluetooth, USB, and network boot. The system on chip, or SOC, is quicker than the Pi 2 and Pi 3 models because it combines the CPU and GPU into a single device. The Raspberry Pi 3B+'s central processing unit, or CPU, handles its fundamental input/output, logical, and mathe-matical functions. APU and GPU are the two components that make up CPU. Arithmetic processing units, or APUs, are devices that carry out arithmetic operations.GPU means graphic processing unit is a specialized electronic ckt. Using rapidly manipulate and after memory to accelerate creation of image in a frame buffer intended for output to a display. BCM 2837B0 chip is used in the raspberry pi 3B+.There are 2 USB ports and POE header.It has 40 GPIO pins and 4 pole

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stereo output and com- posite video port.It has CSI and DSI.CSI means camera serial inter-face and DSI means display serial interface.Raspberry pi 3B+ get supply from power supply regulator and it also takes signal from camera whenever it sense green plant.

Fig. 1. Hardware kit of Raspberry pi 3B +

2) Relay

An electrically powered switch is called a relay. A lot of relays use an electromagnet to mechanically control a switch, however different operating standards are also used. Relays of the 12V, 10A electromagnetic attraction type work by using electromagnetic attraction. This kind of magnetic switch generates a magnetizing field using a magnet. The switch is then opened and closed and the mechanical operation is carried out by the magnetic field. The Raspberry Pi 3B+ is connected to the camera. The Raspberry Pi 3B+ receives a signal from the camera whenever it detects a green plant. The relay driver receives the B+ signal from the Raspberry Pi 3, and the relay then functions. From now on, the motor will turn on via relay operation.

3) Bluetooth model HC-05

A Bluetooth module called the HC-05 is made for wireless communication. It communicates with devices via serial communication. The serial port (USART) is used for communication with the microcontroller. The first of its six pins, Key/EN, is used to switch the Bluetooth module into AT commands mode. This module operates in command mode if the Key/EN pin is set too high. Otherwise, it is in data mode by default. The HC-05's default baud rates are 38400bps in command mode and 9600bps in data mode. The HC-05 module has two modes: Data mode, which allows devices to exchange data. Command mode: It makes use of AT commands to modify the HC-05's settings. These commands are sent to the module via the serial (USART) port. 2. VCC: Attach either 3.3 V or 5 V to this pin. 3. GND: The module's ground pin. 4. TXD: Transmit Serial Data (data from a Bluetooth module that is wirelessly received and serially sent out on the TXD pin) 5. RXD: Receive data serially; a Bluetooth module will send the data wirelessly. 6. State: Indicates if the module is connected.

Fig. 2. HC-05 Module

4) DC motors

DC Geared Motors: Because of its great torque, effectiveness, and controllability, a DC gear motor is utilized in autonomous agricultural robots for sowing and pesticide application. A 12V or 24V motor (5–15 Nm torque, 50–300 RPM) powers the pump and regulates nozzle movement during spraying. A high-torque motor (10–20 Nm, 30-200 RPM) guarantees accurate seeding and planting. These motors are energy-efficient, compact, and easily controlled via microcontrollers, making them ideal for battery- powered agricultural automation.

Fig. 3 DC Geared Motor

5) L293D Motors driver

L293D is a typical Motor driver or Motor Driver IC which allows DC motor to drive on either direction.
Specifications:
a. Maximum Peak motor current: 1.2A
b. Maximum Continuous Motor Current: 600mA
Supply Voltage to Vcc1(vss): 4.5V to 7V Automatic Thermal shutdown is available Available in 16-pin DIP, TSSOP, SOIC packages Automatic Thermal shutdown is available Available in 16-pin DIP, TSSOP, SOIC packages

Fig. 4. L293D Motors driver

6) Sensor of Soil Moisture

In precision agriculture, a soil moisture sensor is an important instrument for effective water management and automated irrigation. These sensors measure soil moisture levels accurately using resistive, capacitive, or tensiometric principles. They usually operate in the voltage range of 3.3V to 5V and offer digital or analog output for monitoring in real time. Capacitive sensors, with corrosion-resistant probes, offer increased longevity compared to resistive kinds.
With a wide measuring range, fast response time (¡1s), and seamless interaction with microcontrollers, soil moisture sensors boost crop output and sustainability by optimizing irrigation techniques

Fig. 5. Soil Moisture Sensor

7) Servo Motor

A servo motor is a precision actuator used in robotics, automa- tion, and agriculture for accurate position and speed control. Operating on a closed-loop system with PWM signals, it typically runs on 5V to 24V with torque ranging from 0.1 Nm to several Nm. Its high efficiency, fast response, and precise angular control make it ideal for robotic arms, automated spraying, and seeding in smart farming applications.

Fig. 6. Servo motor

8) Battery

A 12V battery is a critical power source in robotics, autonomous systems, and precision agriculture, offering stable energy for various applications. Common types include Lead- Acid, Lithium-ion (Li-ion), and Lithium Iron Phosphate , each varying in energy density, cycle life, and efficiency. These batteries typically provide capacities ranging from 1Ah to 100Ah, with energy densities between 30–250 Wh/kg. batteries are preferred for their long cycle life (2000–5000 cycles) and enhanced safety features. With a charging voltage of 12.6V–14.6V, they effectively power DC motors, sensors, and control systems in autonomous agricultural robots, facilitating applications such as spraying, seeding, and irrigation automation.

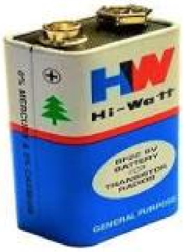

Fig. 7. Battery

B. Methods

Data collection: User inputs (through an Android app) assist in configuring operational parameters, while sensors including moisture sensors gather soil data.

Autonomous Navigation: The robot uses preset routes to navigate.

Seeding Mechanism: To guarantee ideal plant growth, the robot delivers seeds at set times based on soil moisture levels.

Pesticide Spraying: The robot uses its spraying mechanism to evenly apply pesticides to the crops when pest control is required.

Real-time Monitoring: For remote tracking and intervention, the system sends real-time updates to the user's mobile application.

III. RESULTS AND DISCUSSION

By checking important parameters including efficiency, precision, time optimization, and using resources, the suggested model's performance is assessed. This analysis aids in figuring out how effectively the robot achieves the goals of autonomous pesticide spraying and sowing while maximizing agricultural output.

Metric	**Manual Method**	**Proposed Robot**
Seeding Accuracy (%)	75	92
Pesticide Efficiency (%)	65	90
Coverage Area(sq.m/min)	10	25
Time Efficiency(sec/task)	180	85
Power Consumption(W)	-	15

Table 5.1: Traditional vs. Robotic Approach Performance Comparison

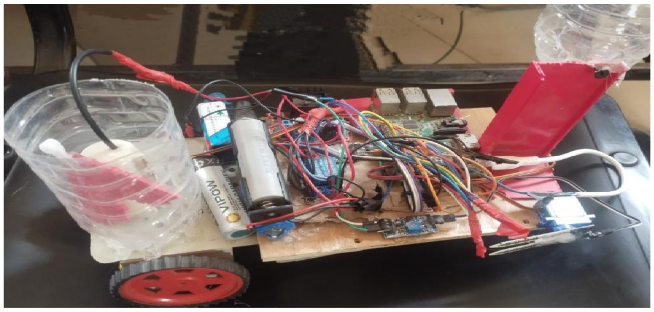

Fig. 8. Actual image of proposed work

IV. CONCLUSION

The creation of a multi functional agricultural robot that can spray pesticides and plant seeds on its own offers a revolutionary answer to the problems facing current farming. Through the integration of modern robotics, machine learning, and intelligent sensor technology, this robot seeks to improve agricultural techniques' sustainability, accuracy, and efficiency. By mixing necessary farming operations into a single machine, the suggested solution offers versatility while filling significant holes in current techniques. Farmers may concentrate on other crucial areas of their operations because of its autonomous operation, which reduces the need for physical labor. Additionally, real-time data use guarantees resource efficiency, which increases crop yields and lessens their impact on the environment.

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