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Agricultural Pesticide Spraying Robot Car

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ABSTRACT

The advancement of automation in agriculture is critical in addressing the growing concerns of labor shortages, overuse of pesticides, and the health hazards faced by farmers due to manual spraying methods. In response to these challenges, the development of a Bluetooth-controlled agricultural pesticide spraying robot car offers a sustainable and low-cost solution. This paper reviews the design, implementation, and performance of a robotic spraying system that leverages embedded systems and wireless communication to control pesticide distribution efficiently. The system uses an Arduino UNO microcontroller, DC motors, servo motors, Bluetooth communication via an HC-05 module, and a 12V DC water pump to execute spraying functions precisely. The robot is controlled using an Android application, allowing farmers to manage the direction, movement, and spray mechanism remotely. This reduces direct contact with harmful chemicals, optimizes pesticide usage, and enhances spraying accuracy. Through a comparative literature review and practical implementation, this paper highlights the impact of such low-cost robotic innovations in revolutionizing small to mid-scale farming practices

I. INTRODUCTION

1.1 History :

Agriculture remains the cornerstone of food security and rural livelihoods, especially in developing nations. However, the sector continues to face significant challenges in terms of labor availability, cost-efficiency, and safety—particularly when it comes to pesticide application. Manual spraying is not only labor-intensive but also poses serious health hazards to farm workers who are exposed to toxic chemicals. Moreover, traditional spraying methods often lead to excessive chemical usage, uneven application, and environmental contamination through runoff and drift. In an age where technological integration is redefining productivity across sectors, agriculture too is embracing automation and embedded technologies to address these critical issues. Among these innovations, robotic pesticide spraying systems are emerging as a promising solution. This paper presents a review and analysis of one such system—the Agricultural Pesticide Spraying Robot Car—which uses embedded control and wireless communication to perform precise, remote-controlled pesticide application in farms.

1.2 Robotic Automation in Agriculture:

Agricultural robotics, or Agri-bots, are transforming farming practices by automating repetitive and risky tasks. These systems reduce dependency on manual labor and ensure consistency in operations like planting, harvesting, and pesticide application. The Pesticide Spraying Robot Car falls under this category of automation. It employs motor drivers, microcontrollers, and wireless communication to replace the manual pesticide spraying process with a remotely operated robotic platform. The goal is to enhance worker safety, reduce operational costs, and improve spray precision—all while being affordable and easy to use for small to medium-scale farmers.

1.3Embedded Systems for Smart Spraying:

Embedded systems lie at the core of modern automation. In this project, an Arduino UNO microcontroller integrates various hardware components—DC motors, servo motors, a relay-driven pump, and a Bluetooth communication module—to control the robot's movement and spraying mechanism. The use of an Android mobile application provides a simple user interface, enabling real-time directional control and targeted spraying. This modular design allows customization and scalability, opening doors to future enhancements such as GPS integration or sensor-based automation. By leveraging embedded systems, this robot ensures efficient, controlled, and safe pesticide application in the field.

2. LITERATURE SURVEY

Sushma Priya [1] (2022) "Agricultural Pesticide Spraying Robot" This research describes a pesticide spraying robot controlled by an Android app through Bluetooth. The system uses an Arduino UNO microcontroller, HC-05 Bluetooth module, and L293D motor driver to control four DC motors. It minimizes manual involvement in spraying tasks and ensures safety and cost reduction for small-scale farmers. However, the system is semi-automated and dependent on the operator's constant attention.

R. S. Kawitkar [2] (2016) – *"Smart Agriculture Using IoT"* This study discusses the application of IoT technologies to automate multiple agricultural functions such as irrigation, pest control, and monitoring. It presents an architecture using real-time sensors and wireless control. While it does not focus solely on spraying, the concepts laid out support integrating pesticide systems into smart farm environments for better decision-making and efficiency.

N. Bharath [3] (2019) – *"Design and Implementation of an Autonomous Pesticide Spraying Robot"* This paper introduces a fully autonomous robot equipped with ultrasonic sensors for obstacle detection and navigation in crop fields. It reduces human dependency and provides consistent spraying. Though efficient in its mobility and coverage, it lacks real-time adaptability and depends on pre-coded navigation logic.

A. Lavanya [4] (2016) – *"Design of Agriculture Robot for Spraying Fertilizer and Pesticide"* The authors developed a low-cost robot capable of spraying fertilizers and pesticides using DC motors and basic electronic components. It is suitable for small farms and demonstration purposes. The paper suggests future enhancements through GPS or AI to improve navigation and spraying control.

Sanket B. Jadhav [5] (2019) – *"IoT Based Smart Pesticide Sprayer"* This paper presents a prototype pesticide spraying system integrated with IoT for cloud-based control and monitoring. It allows users to remotely activate and supervise the spray mechanism. Although highly informative on cloud integration, it lacks the mobility component necessary for full field coverage.

R. Krishnamoorthy [6] (2020) – *"Smart Farming Based on IoT and Cloud Computing"* The study proposes a comprehensive framework for smart farming using IoT devices and cloud platforms. It incorporates modules for soil sensing, irrigation, and pest control. While pesticide spraying is a submodule, the emphasis is on overall system integration and the need for real-time data-driven decision-making in agriculture.

R. Vikram [7] (2020) – *"Agricultural Robot – A Pesticide Spraying Device"* This research proposes a robotic sprayer that dynamically adjusts its nozzle based on crop distance using sensors. It enhances spray precision and minimizes pesticide waste. However, due to sensor complexity and potential calibration challenges, it may be costlier or harder to implement in budget-restricted farms.

Aravind K. (2020) – *"Automated Pesticide Sprayer Using IoT"* This project presents an IoT-based pesticide spraying unit that can be controlled via Wi-Fi using a smartphone. It is effective for greenhouse or indoor farming setups. The paper focuses more on real-time connectivity than mobility, making it limited to fixed-location spraying applications.

3.BLOCK DIAGRAM

3.1 Block Diagram:

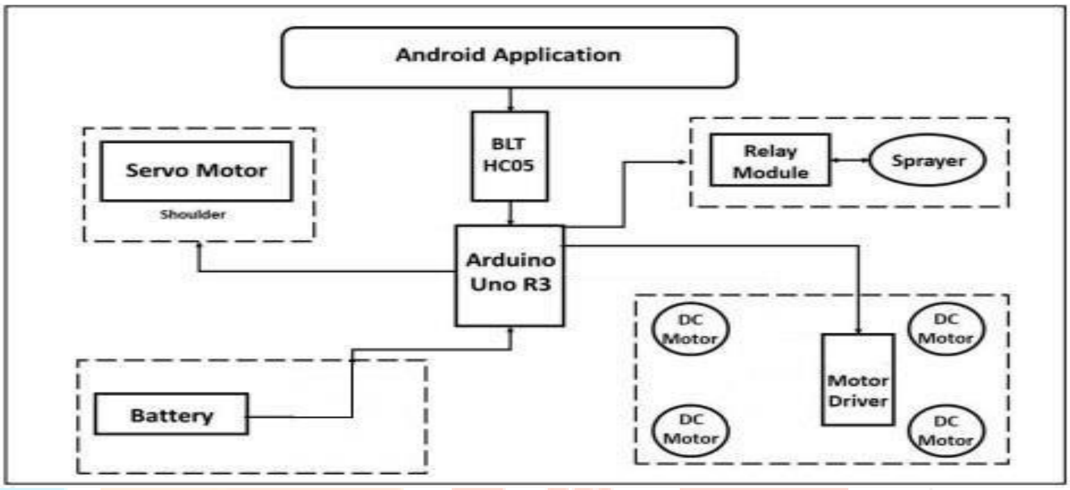

Fig 1: Block Diagram

The block diagram illustrates a Pesticide Spraying Robot Car designed to automate the spraying process in agricultural fields. At the core of the system is an Arduino Uno R3 microcontroller, which receives user commands via a Bluetooth module (HC-05) connected to a mobile application. This wireless communication allows the user to control the robot remotely, improving both safety and ease of operation. Based on these commands, the Arduino controls a servo motor to adjust the sprayer's direction, a relay module to activate or deactivate the sprayer, and a motor driver (L293D) that operates four DC motors for movement. These components work together to navigate the robot across the field and accurately spray pesticides where needed. A rechargeable battery powers the entire system, ensuring portability and usability in outdoor farming environments. This automated setup not only increases spraying efficiency but also reduces manual labor and minimizes the risks associated with direct exposure to harmful chemicals. It offers a smart and practical solution to modern agricultural challenges, enhancing both productivity and safety.

3.1 Control Unit

- Components Covered: Arduino Uno R3, Bluetooth Module (HC-05)
- The Arduino Uno serves as the central processing unit, receiving commands from the mobile app via the Bluetooth module.
- It controls the movement, sprayer operation, and angle adjustment based on inputs received wirelessly.

3.2 User Interface & Communication:

- Components Covered: Android Application, 2-Pin ON/OFF Switch
- The Android application acts as the user interface, allowing control of the robot through a graphical UI.
- The 2-pin switch acts as a main power control for the system
- Commands such as move, stop, spray ON/OFF, and adjust direction are sent via Bluetooth.

3.3. Locomotion System:

- Components Covered: Motor Driver (L298N), 4 DC Motors
- The motor driver receives signals from the Arduino and powers the 4 DC gear motors.
- These motors provide forward, backward, left, and right movement across uneven farm terrain.

3.4 Sprayer Mechanism:

- Component covered: Relay Module, DC Pump.
- The relay module acts as a switch to activate or deactivate the sprayer.
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- When turned ON, the 12V pump draws pesticide from the tank and sprays it onto crops

3.5 Directional Supply & Power Supply:

- Components Covered: Servo Motor, Battery
- The servo motor is used to change the angle/direction of the sprayer for targeted spraying
- The battery supplies power to all electronic and mechanical components

4. METHOLOGY AND SYSTEM DEVELOPMENT

The development of the Agricultural Pesticide Spraying Robot Car followed a structured methodology, beginning with an in-depth literature review to understand existing technologies in agricultural automation. The system was carefully designed and developed using both hardware and software components such as Arduino Uno, Bluetooth communication, DC motors, a relay-based sprayer mechanism, and an Android interface. Each component was integrated to ensure seamless functionality. The design process emphasized modularity and field applicability. Rigorous experimentation and testing were conducted to validate system performance, including mobility, spraying efficiency, and wireless responsiveness. The outcomes were then analyzed to assess accuracy, reliability, and potential areas of improvement. Finally, all findings and technical details were documented systematically, and the results were disseminated through academic channels and project demonstrations to contribute to future advancements in smart farming solution.

4.1. Literature Review:

Gather and analyze existing research on agricultural automation, pesticide spraying systems, and mobile robot technologies**.**

Review sources such as academic journals, IEEE papers, agricultural tech conferences, and robotics project repositories.

Understand current technologies, including Bluetooth-controlled robots, Arduino-based automation, motor control systems, and spraying mechanisms.

Identify research gaps such as limited spraying accuracy, lack of automation in small-scale farming, and high dependency on manual labour.

Evaluate agricultural needs, cost-effectiveness, environmental impact, and the potential of robotic spraying to improve farming efficiency

4.2Design and Development:

The Arduino Uno R3 acts as the central controller, receiving wireless commands from an Android application via the HC-05 Bluetooth module

Evaluate agricultural needs, cost-effectiveness, environmental impact, and the potential of robotic spraying to improve farming efficiencydriver, enabling forward, backward, and turning motions.

A servo motor is used to adjust the direction of the sprayer, while a relay module controls the DC water pump for pesticide spraying.

A 6V/12V battery powers the entire system, with a 2-pin switch for overall control.

The robot was programmed using Arduino IDE, and field-tested to ensure proper mobility and effective pesticide application.

4.3. Experimentation and Testing:

- The robot was tested on various field surfaces to check the stability, traction, and maneuver ability of the DC motors.
- Bluetooth communication was verified for effective command reception from the Android app, ensuring smooth directional control and real-time response
- The sprayer system, including the pump and relay, was tested for consistent pesticide output. Adjustments were made to control spray duration and flow rate.
- The servo motor was calibrated to ensure proper nozzle alignment, allowing for targeted spraying over crop rows.
- Overall functionality was validated by running the robot through sample spraying routines, confirming coordination.

4.4. Evaluation and Analysis:

Functionality: The robot successfully performed all intended operations, including navigation, spraying, and directional control through the Android app.

Accuracy: The servo-assisted spraying mechanism provided targeted pesticide application with minimal overspray, increasing precision and reducing chemical wastage.

Response Time: Bluetooth communication showed low latency, with smooth and immediate execution of commands.

Efficiency: The system reduced manual effort and optimized pesticide usage, making it suitable for small to medium-scale farms.

Limitations: Battery life and limited Bluetooth range were identified as constraints. Future versions can incorporate solar panels or GSM/Wi-Fi modules for extended operation and remote access.

4.5. Documentation and Dissemination:

A detailed project report was prepared, covering the system design, hardware integration, software implementation, testing results, and analysis.

Circuit diagrams, code listings, and block diagrams were included to support replication and improvement by future students or researchers.

The findings and technical content were aligned with academic formats to allow publication in student journals, review papers, or IEEE conferences.

The project was also demonstrated in institutional reviews and final-year project exhibitions to disseminate its potential benefits to the academic and agricultural communities.

Future plans include publishing a condensed version of the report in a recognized journal to contribute to the growing field of smart farming and agricultural robotics.

5. CONCEPT VISUALIZATION/IDEAL SCENARIO/PROTOTYPE BLUEPRINT

The advanced version of the current system is provided by this anticipated model. It blends two core ideas: automation and precision-based agricultural spraying.

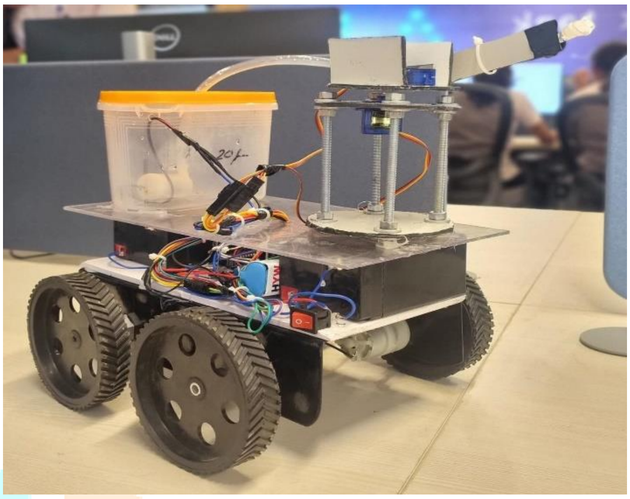

Fig 5.1 Architecture of Proposed System.

The architecture of the proposed system is depicted in Figure 5.1 above. It features a compact four-wheel robotic base driven by high-torque DC motors, capable of navigating farm terrain. A pesticide container is securely mounted at the rear, connected to a DC pump that is activated wirelessly. The sprayer is mounted on an adjustable arm controlled by a servo motor, enabling directional spraying. All components are assembled on a transparent acrylic platform, allowing for efficient wiring and visibility of the internal system. The robot is wirelessly operated via an Android application through a Bluetooth module, providing real-time control over movement and spraying. This smrt agricultural prototype

demonstrates how low-cost automation can reduce human effort, minimize pesticide wastage, and enhance safety in farming environment.

6.CONCLUSION:

The development of the Agricultural Pesticide Spraying Robot Car marks a significant step toward automation in agriculture. By integrating microcontroller-based control with wireless communication and motor-driven mobility, the system effectively reduces human involvement in hazardous pesticide spraying tasks. The robot offers a portable, low-cost, and user-friendly solution that not only increases operational efficiency but also promotes safe and precise pesticide application. Field testing demonstrated reliable performance in terms of mobility, control responsiveness, and spray accuracy. With further enhancements such as GPS navigation or solar-powered operation this model holds strong potential to contribute to the future of smart and sustainable farming.

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