Smart Pesticide Sprayer Robot Using IOT In Agriculture Field

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Abstract

In modern agriculture, the excessive use of pesticides and manual spraying methods pose significant health and environmental risks. project proposes a Smart Pesticide Sprayer Robot integrated with Internet of Things (IoT) technology, aimed at automating and optimizing pesticide application in agricultural fields. The robot is designed to navigate through crops autonomously using sensors and a microcontroller, identifying affected areas for targeted spraying. Real-time monitoring and control are enabled through IoT connectivity, allowing farmers to track field conditions, spraying status, and pesticide levels via a smartphone or web interface. This system reduces human exposure to harmful chemicals, minimizes pesticide wastage, and enhances overall efficiency and crop health. By leveraging automation and smart technology, the robot supports sustainable and precision agriculture practices.

*Agriculture is the backbone of economies, and with increased efficiency and sustainability in farming practices. One of the major concerns in agriculture is the excessive and non-uniform use of pesticides, Traditional pesticide spraying methods are often manual, time-consuming, and pose health risks to farmers due to direct exposure tochemicals. To address these issues, we propose a Smart Pesticide Sprayer Robot that us**es** IoT .technology to automate the spraying process in agricultural fields.*

The robot is designed to navigate through crop rows using obstacle detection sensors and path-following algorithms. It sprays pesticides only in the required areas, reducing wastage and environmental impact. The system includes a moisture and temperature sensor to collect real-time data on field conditions. This data is sent to a cloud platform via Wi-Fi or GSM, allowing remote monitoring and control. Farmers can access this information through a smartphone app or web interface to make data-driven decisions. The robot is controlled by a microcontroller, such as Arduino or Raspberry Pi, and powered by rechargeable batteries or solar panels. An ultrasonic or IR sensor system ensures

1 INTRODUCTION

the economic development of many countries, providing food, raw materials, and employment to a large portion of the population. However, the numerous challenges, such as labor shortages, inefficient farming practices, and the overuse of chemicals like pesticides. Traditional pesticide spraying methods are often labor-intensive and expose farmers to serious health problems. In addition, the uncontrolled and excessive use of pesticides can damage the environment, contaminate soil and water, and affect crop quality.

To overcome these challenges, automation and in agriculture—often referred to as smart farming—offers innovative and effective solutions. The Smart Pesticide Sprayer Robot is one such advancement aimed at making pesticide application more efficient, safe, and precise. This robot automates the pesticide spraying process by using sensors and programmed navigation to move through crop fields and spray only when and where it is needed. the unnecessary use of chemicals, protecting both the environment and human health.

2 LITERATURE SURVEY

Recent advancements in agricultural automation have led to the development of smart systems aimed at reducing manual labor and increasing efficiency. Various autonomous robots in agriculture for tasks such as seeding, irrigation, and pesticide spraying. Research published in journals like the *Research in Electrical, Electronics and Instrumentation Engineering* highlights the growing importance of robotics and IoT in precision farming. These crop health and apply inputs like pesticides environmental impact and improving crop yields.

develop pesticide sprayer robots with different control mechanisms. Some systems use GPS-based navigation, while others rely on ultrasonic or infrared sensors for path tracking and obstacle detection. For example, a study by researchers at IIT Kharagpur introduced an autonomous to identify pests and spray pesticides accordingly. However, many of these systems lack real-time remote monitoring and user-friendly widespread adoption by farmers, especially in rural areas. These limitations point to the potential benefits of incorporating IoT-based controls and data logging for better decision-making.

IoT-based agricultural systems have shown promise in various applications, from automated irrigation to weather monitoring. When applied to pesticide spraying, IoT allows for optimization of chemical use. Studies *of Agricultural Science and Technology* have demonstrated that IoT-enabled devices can significantly reduce input costs by monitoring field conditions and controlling actuators based on real-time data. These findings pesticide spraying spraying through data analytics.

3 METHODOLOGY

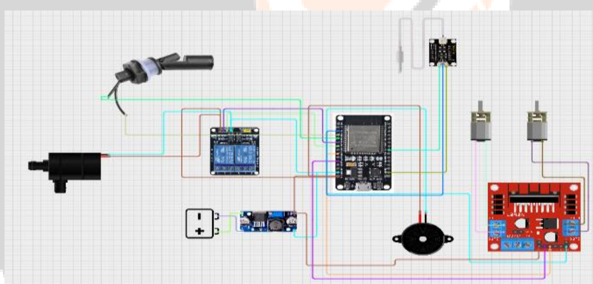


Figure 3.1: Flow Chart of smart pesticide sprayer robot using iot in agriculture field

1. System Design and Planning

The initial phase focuses on defining the system architecture and selecting the necessary hardware and software components. includes a microcontroller (such as Arduino or Raspberry Pi), motor driver circuits, a pesticide spraying mechanism, and various sensors. A chassis is designed for the robot with wheels or tracks to enable movement across different types of terrain in the field.

2. Hardware Implementation

The hardware setup involves assembling the robot platform with components such as:

- Ultrasonic/IR sensors for obstacle detection and navigation,
- Temperature and conditions,
- Motor and pump system to enable movement and pesticide spraying,
- Water/pesticide tank mounted securely on the robot frame.

DC motors are interfaced with the microcontroller for locomotion, while a relay or motor driver controls the pesticide spraying motor. Solar panels or rechargeable batteries are included as a power source to make the system eco-friendly and mobile.

3. Software Development and IoT Integration

The software section includes programming the microcontroller to control robot movements, read sensor data, and activate the spraying mechanism. IoT functionality is or NodeMCU, which cloud platform such as ThingSpeak, Blynk, or Firebase. A dashboard is used to display data, provide alerts, and allow remote control of the robot.

4. Testing and Field Deployment

After assembling the hardware and configuring the software, the robot undergoes several test runs in a controlled environment. It is tested for navigation accuracy, obstacle avoidance, sensor response, and spraying precision. Once validated, the system is deployed in a real agricultural field to evaluate performance under actual farming conditions. Data is collected and analyzed to refine the control algorithm and optimize the pesticide usage.

 ESP8266 NodeMCU Microcontroller

- The central controller of the system, controlling the robot’s movement, and managing the web interface and hardware. The ESP8266 offers built-in Wi-Fi for wireless control via the web interface.

 TDS (Total Dissolved Solids) Sensor

- Measures the concentration of dissolved solids in the pesticide solution. The sensor helps ensure that the pesticide solution is within the desired concentration range before the sprayer is activated. This prevents over- or under-spraying of chemicals.

 Water Level Sensor

- Monitors the liquid level in the pesticide tank. The sensor ensures that the sprayer does not activate if the liquid level is too low or empty, protecting the pump and preventing inefficient spraying.

 DC Motors

- Drives the movement of the robot, allowing it to move forward, backward, left, and right. The motors provide the necessary motion for navigation in the field.

 L298N Motor Driver

- Used to control the DC motors. The L298N movement.

 Relay Module

- Controls the pesticide pump. When the TDS sensor indicates that the solution is in the correct range, and the water level is sufficient, the relay activates the pump to start spraying.

 Mini DC Pump (Sprayer)

- The pump is used to spray the pesticide solution onto the crops. It is controlled by the relay and is activated when the conditions are met (appropriate TDS value and sufficient water level).

 Power Supply

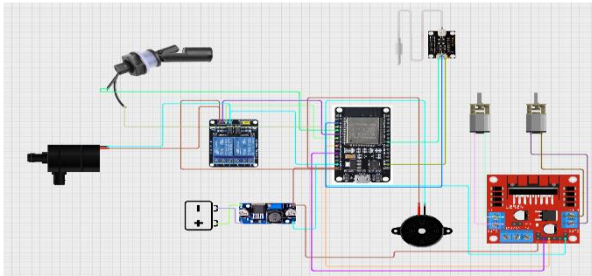
- A rechargeable battery or an external power the ESP8266, motors, sensors, and pump.

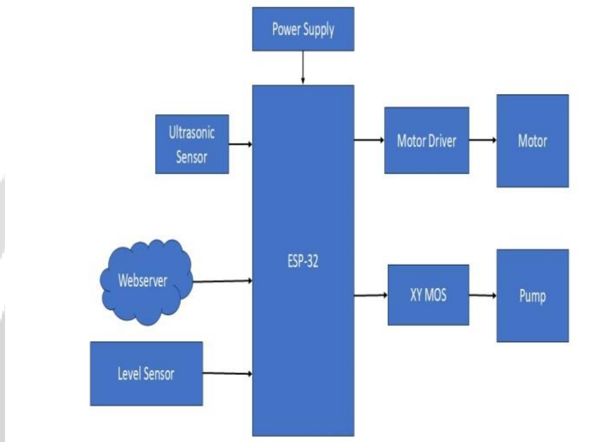
 Web Interface (Mobile/Webpage)

- Allows the user to control the robot remotely via a smartphone or computer. The web interface provides a user-friendly dashboard to monitor sensor data (TDS value, water level), control the robot’s movement, and activate the spraying system.

3.3 ACTIVITY DIAGRAM

3.3.1 SCHEMATIC DIAGRAM





8x8 LED

Figure 3.2 Block diagram

1. Power Supply

- The voltage and current to all electronic components in the system.
- It ensures the ESP-32, sensors, motors, and pump receive stable and sufficient power for operation.
- It can be sourced from a battery pack, potentially rechargeable or solar-powered for field use.

2. ESP-32 Microcontroller

- The ESP-32 is the core controller of the system. It manages all inputs from sensors and issues outputs to actuators.
- It features built-in Wi-Fi and Bluetooth, enabling seamless IoT connectivity for real-time monitoring and control.
- It processes data from the ultrasonic and level sensors, controls the motor and pump via drivers, and communicates with a cloud server.

3. Ultrasonic Sensor

- The ultrasonic sensor is used for obstacle detection.
- It emits ultrasonic waves and measures the time taken for the echo to return, calculating the distance to nearby objects.
- This helps the robot avoid obstacles while moving in the field, ensuring safe navigation.

4. Motor Driver

- ESP-32 DC motors.
- It amplifies the low-power ESP-32 to the higher currents required motors.
- It controls the movement (forward, backward, turning) of the robot.

5. Motor

- The motor provides mechanical movement to the robot.
- It drives the wheels or tracks, allowing the robot to navigate the field autonomously under the command of the ESP-32.

6. XY MOS (MOSFET Switch)

- This switch used pesticide spraying pump.
- ESP-32 and allows or blocks pump.
- Provides efficient and fast switching with minimal power loss.

7. Pump

- The pump is used to spray pesticides onto crops.
- It draws pesticide fluid from the tank and sprays it through nozzles when activated.
- Controlled by the XY MOS based on commands from the ESP-32.

8. Level Sensor

- This sensor monitors the pesticide level in the tank.
- It sends real-time data to the ESP-32, which can trigger an alert or stop the pump if the pesticide level is too low.

4 Results And Discussion

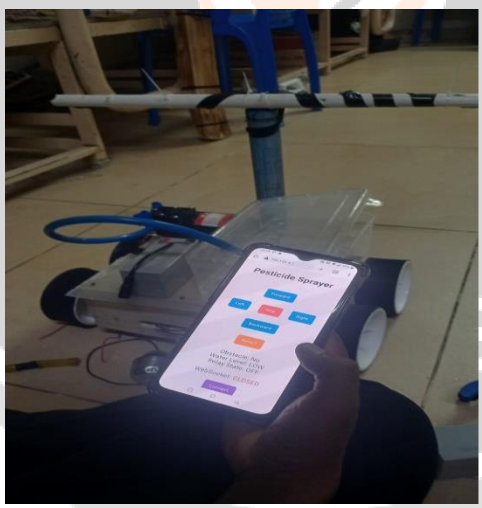
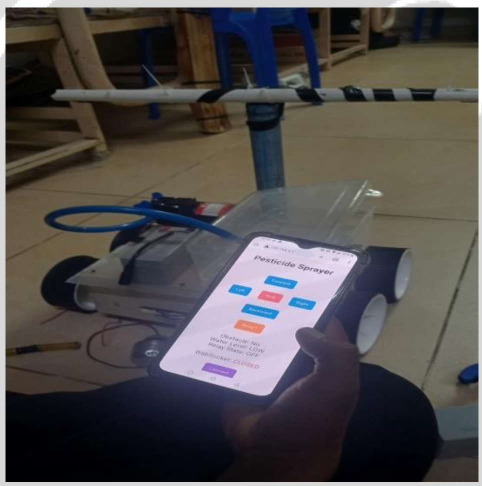


Fig 4.1: Project Model – smart pesticide sprayer robot using iot in agriculture field

The ESP8266-based pesticide sprayer system was successfully implemented and tested. The system allowed remote and automated pesticide spraying mechanism through Wi-Fi connectivity. It responded effectively to sensor inputs (such as soil moisture or temperature and humidity) and triggered the spraying motor accordingly. The pesticide was sprayed uniformly over the target area, and the system operated with low power and minimal human intervention.

Fig 4.2: Battery charging

The ESP8266 microcontroller with IoT technology in the pesticide sprayer system proved to be both cost-effective and efficient. of Wi-Fi enabled real-time monitoring is especially beneficial in large or remote agricultural fields. Sensor data allowed for smart decision-making, ensuring that spraying occurred only under suitable environmental conditions, reducing pesticide wastage and environmental impact. However, challenges such as limited Wi-Fi range in rural areas stable power source were noted. These can be addressed in future improvements using long-range communication (e.g., LoRa) and solar-powered battery for modernizing traditional farming practices and enhancing precision agriculture.



4.3 ESP8622 Remote control system

The Smart Pesticide Sprayer Robot incorporates remote control functionality through IoT integration, allowing farmers to operate and monitor the robot from a distance using a smartphone, tablet, or computer**.** This feature enhances user convenience, reduces labor, and ensures safe pesticide application without requiring the farmer to be physically present in the field.

At the core of this system is the ESP-32 microcontroller**,** which comes with built-in Wi-Fi capabilities. The robot connects to the internet through a local Wi-Fi network and communicates with a cloud-based platform **or a** dedicated web server. Data from sensors such as the ultrasonic sensor (for obstacle detection) and level sensor (for pesticide tank monitoring) is continuously cloud.

Farmers can access a web (e.g., Blynk, Firebase, or custom dashboard) to view real-time data such as:

- Pesticide tank level
- Robot's movement status
- Environmental readings (if sensors like temperature/humidity are added)

Spraying status allows remote commands to be issued, including:

- Start/Stop spraying

The interface also Move forward/backward

- Turn left/right
- Return to home/charging station (if GPS or beacon system is included)
- Alerts for low tank levels or obstacles

This remote control capability minimizes human exposure to harmful pesticides and allows more efficient field management, especially for large farms. It also enables remote troubleshooting and updates, making it a practical solution for modern, connected agriculture.

5. Future Enhancement

The of the automated pesticide spraying system can focus on improving efficiency, scalability, and intelligence. One potential improvement is the integration of machine learning algorithms to analyze environmental data more accurately, enabling the system to adjust spraying patterns and pesticide amounts based on real-time conditions crop health, and weather data. system can be enhanced with GPS and mapping capabilities, allowing it area and perform targeted spraying, ensuring precise application and Energy efficiency improved by incorporating solar power as an auxiliary energy source, extending the operational time of the system in remote areas. Furthermore, the use of advanced sensors, like cameras or spectral sensors, can enhance the system's ability to detect crop diseases or pest infestations, automating pest control beyond just spraying. Communication protocols can be upgraded to 5G or low-power wide-area networks (LPWAN) for faster and more reliable remote monitoring and control, enabling integration with larger smart farming ecosystems. These enhancements would make the system more autonomous, scalable, and responsive, transforming it into for precision agriculture.
Proposed Future Enhancements:
Proposed Future Enhancements for the automated pesticide spraying system could focus on improving precision, efficiency, and adaptability. Some potential areas for enhancement include:

1. Integration with GPS for Precision Mapping: By incorporating GPS technology, the system can map the spraying area more accurately. targeted pesticide application, ensuring minimal waste and reducing the environmental impact. GPS integration would enable the system to create spray patterns and path taken across the field.

2. AI for Adaptive Control: The system could be enhanced that analyze environmental conditions in real-time, conditions, and pest population. These insights system to dynamically adjust pesticide spraying based on the crops, improving efficiency and effectiveness.

3. Advanced Sensor Integration: The addition of camera-based systems or spectral sensors could help detect crop. This would allow the system to perform not only spraying but also pest detection and disease prevention, making the system more intelligent and versatile.

4. Solar Power Integration: To improve energy efficiency and extend operational time, solar panels could be added to the system. Solar energy would, reducing dependency on batteries and ensuring continuous operation in off-grid or remote locations.

5. Automated Maintenance Alerts: The system could be enhanced with self-diagnostic capabilities, where it monitors components like motors, pumps, and sensors. If a component malfunctions or requires maintenance, the system can automatically send alerts to the user, preventing operational downtime.

6. Enhanced Communication advanced communication protocols, such as 5G (LPWAN), to ensure the robot user's mobile app or central control system. This would allow for real-time monitoring and control even in vast fields or remote locations.

7. Battery Optimization: Integrating smart battery management systems (BMS) would optimize the energy consumption and charging cycles of the battery. The system could also monitor battery health and estimate its remaining life, ensuring uninterrupted service during spraying tasks.

8. Multi-Robot Coordination: In larger-scale agricultural operations, multiple robotic sprayers could be deployed and controlled simultaneously. The system could be enhanced with multi-robot coordination algorithms to allow multiple units to work together efficiently, covering larger areas without overlapping or missing spots.

9. Drone Integration: Adding drone technology to the system could further extend its capabilities. cover vast areas more quickly, perform aerial spraying, or even gather additional environmental data from the sky for better decision-making.

6 Referances

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