ISSN: 2249-7196
IJMRR/July-September 2026/ Volume 16/Issue 3/57-66
K. Hansika / International Journal of Management Research & Review

Smart Pesticide Spray Monitoring System

Ms. K. Virija[1], K. Hansika[2], N. Meghana[3], V. Gowri[4]

Professor: Department of Electronics and Communication Engineering, Bhoj Reddy Engineering College for Women Hyderabad, India

[2,3,4]B. Tech Students: Department of Electronics and Communication Engineering, Bhoj Reddy Engineering College for Women Hyderabad, India

Mail Id: k.hansikareddy202127@gmail.com[2], nainimeghana@gmail.com[3], vasupulagowri@gmail.com[4]

Abstract

The Smart Pesticide Spray Monitoring System is a simple, cost-effective, and efficient solution designed to improve agricultural practices through controlled pesticide application. This project focuses on the development of an automated system that integrates ultrasonic sensor-based plant detection with software-based plant disease identification to ensure accurate and need-based spraying. The system utilizes an HC-SR04 ultrasonic sensor to detect the presence of plants and measure the distance between the robot and crops for proper positioning during spraying. It also incorporates a software module that allows farmers to upload images of plant leaves for disease identification and assessment of infection severity. Based on the analysis, the appropriate pesticide can be selected and applied through an automated spraying mechanism. The spraying operation is performed using pumps and nozzles, ensuring uniform, precise, and targeted pesticide application only where required. The system is designed using simple hardware components and embedded control techniques to provide reliable performance, low power consumption, and reduced system complexity. Functional performance is validated through testing of plant detection, disease identification, and automated spraying operations. The implemented system demonstrates efficient pesticide management by reducing chemical consumption, improving crop protection, minimizing farmers' exposure to harmful pesticides, and supporting sustainable smart agriculture practices.

Keywords*—Smart Agriculture, Smart Pesticide Spray Monitoring System, Arduino Uno, HC-SR04 Ultrasonic Sensor, Plant Disease Detection, Image Processing, Automated Spraying, Embedded Systems, Precision Agriculture, Internet of Things (IoT).*

Introduction

Agriculture is a vital sector that supports food production and plays a significant role in the economy. However, farmers face several challenges such as pest attacks, plant diseases, and improper use of pesticides. Traditional pesticide spraying methods require manual effort, consume more time, and expose farmers to harmful chemicals, which can affect their health and the environment. In addition, excessive or incorrect use of pesticides can damage crops and reduce soil quality.

To overcome these problems, the Smart Pesticide Spray Monitoring System is developed as an efficient and automated solution for modern agriculture. This system uses an ultrasonic sensor to detect the presence of plants and measure the distance between the robot and crops, enabling safe and accurate navigation in the field. Based on this detection, the system sprays pesticides automatically using pumps and nozzles, ensuring that chemicals are applied only where needed.

Furthermore, a software-based solution is integrated into the system to help farmers identify plant diseases. By uploading images of plant leaves, the software analyzes and detects the type of disease along with its level of infection. Based on this information, farmers can select and fill the appropriate pesticide in the container, ensuring effective treatment.

This combination of hardware automation and software intelligence helps reduce pesticide wastage, minimizes manual labor, and improves farmer safety by limiting direct exposure to chemicals. Overall, the system provides a smart and reliable approach to crop protection, enhancing agricultural productivity and promoting sustainable farming practices.

Literature Survey

The **Smart Pesticide Spray Monitoring System** is designed to detect plant diseases and automatically spray pesticides in agricultural fields. The system follows a software-based approach in which farmers upload images of plant leaves to determine whether the plants are healthy or diseased. An ultrasonic sensor is used to detect the presence of plants and maintain the appropriate spraying distance. Based on the disease identified through image analysis, the system sprays pesticide only where it is required. This intelligent approach reduces pesticide wastage, minimizes manual labor, and improves crop productivity, making it a valuable solution for modern precision agriculture.

A **smart system** is an automated technology that monitors and controls agricultural operations using sensors, software, and embedded devices. Such systems reduce human effort, improve efficiency, and enable accurate decision-making. In the proposed system, the **HC-SR04 ultrasonic sensor** measures the distance between the spraying mechanism and the plants. This helps detect the presence of plants and ensures that pesticides are sprayed at the correct distance for effective coverage.

An important feature of the system is **plant disease detection**, where farmers upload images of plant leaves through a software interface. The uploaded images are analyzed to determine whether the plant is healthy or affected by disease, as well as the severity of the infection. Based on this analysis, the system performs **automatic spraying**, activating the pesticide pump only when diseased plants are detected within the required range. This automated operation reduces manual effort and ensures precise pesticide application.

The system also focuses on **reducing pesticide wastage** by spraying chemicals only on infected plants instead of the entire field. This targeted approach minimizes unnecessary chemical usage, lowers production costs, and helps protect the environment. The **image analysis** process plays a crucial role by examining the uploaded plant images using software algorithms to identify diseases accurately and recommend appropriate pesticide treatment.

The **monitoring system** continuously observes crop conditions using sensors and software, enabling farmers to make timely decisions regarding crop protection. A **control unit or microcontroller** manages the operation of the ultrasonic sensor, motors, and pesticide pump by processing input data and controlling the spraying mechanism. The software also identifies the **affected area** of the plant, ensuring that the infected portions receive proper treatment while avoiding unnecessary spraying on healthy plants.

The proposed system is intended for use in **agricultural fields**, where it assists farmers in improving crop management through early disease detection and automated pesticide application. By detecting diseases at an early stage and applying only the required amount of pesticide, the system enhances **crop productivity** while reducing chemical consumption. This **chemical usage control** not only protects soil health and the surrounding environment but also promotes sustainable agricultural practices by ensuring efficient and responsible pesticide application.

Hardware and Software Requirements

Important for the implementation of the Smart Pesticide Spray Monitoring System. The hardware components form the physical structure of the system and help perform various operations. The main hardware used in this project includes the Arduino Uno, ultrasonic sensor, L298N motor driver module, DC motors, servo motor, and a 12V battery. The Arduino Uno acts as the central controller that receives signals from the ultrasonic sensor and controls the movement of the robot and the spraying mechanism. The ultrasonic sensor detects obstacles in front of the system and sends the information to the Arduino. Based on this input, the Arduino controls the motor driver to operate the DC motors for robot movement. The servo motor is used to control the pesticide spraying system. On the software side, the program is developed using the Arduino IDE, which is used to write, compile, and upload the code to the Arduino board. The combination of hardware and software helps the system operate automatically and perform pesticide spraying efficiently.

Hardware Components

Arduino UNO

The Arduino Uno is a widely-used open-source microcontroller board based on the ATmega328P running at 16 MHz, featuring 14 digital I/O pins (6 PWM-capable), 6 analog inputs, a USB connection, barrel power jack (7–12 V input), ICSP header, and reset button. It comes with everything needed to begin prototyping—just plug it into a computer via USB or power it externally.

Figure1; Arduino UNO

Ultrasonic Sensor

An ultrasonic sensor module such as the HC-SR04 Ultrasonic Sensor is generally available with a simplified 3-pin configuration in some versions. The three pins are VCC, GND, and Signal. The VCC pin is used to supply power to the sensor, usually 5V from a controller like the Arduino Uno. The GND pin is connected to the ground of the circuit to complete the electrical path. The signal pin performs both trigger and echo functions, meaning it sends ultrasonic sound waves and receives the reflected waves from nearby objects. The controller measures the time taken for the signal to return and calculates the distance between the sensor and the object. This helps the system detect obstacles and measure distance effectively.

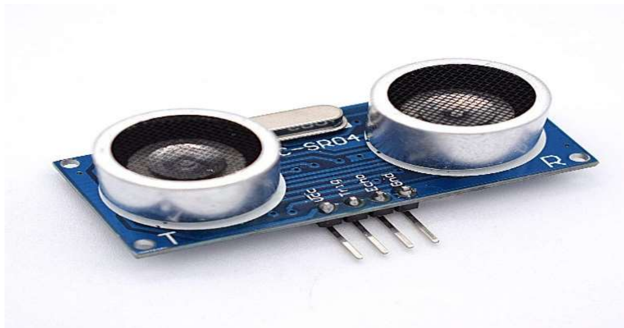

Figure 2; Ultrasonic Sensor

L298N Motor Driver Module

The L298N Motor Driver Module operates with a logic voltage of 5V and can support a motor supply voltage from 5V to 35V. It is capable of driving two DC motors simultaneously using its dual H-bridge circuit. The module can provide a maximum output current of about 2A per channel. It includes enable pins for speed control using PWM signals and input pins to control the direction of the motors. The module also has a built-in 5V voltage regulator, which helps in powering the control circuit. These specifications make the L298N motor driver suitable for controlling motors in robotic and automation applications.

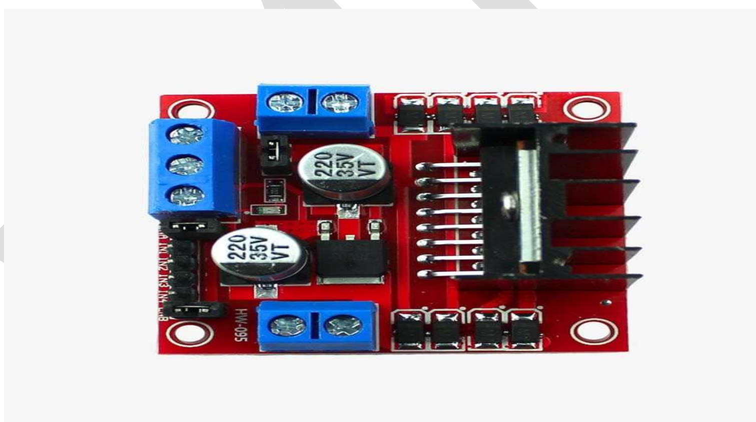

Figure 3; L298N motor driver module

Software Requirements

Pesti Sense – Smart Crop Health Detection System is an AI-based agricultural solution designed to assist farmers in early detection of plant diseases and nutrient deficiencies using leaf image analysis. Developed using Python, the system integrates libraries such as Tkinter, PIL, and NumPy to create a simple and user-friendly interface. It processes uploaded leaf images by analyzing color patterns to identify infections, particularly fungal diseases indicated by brown regions, and calculates an Infection Severity Index (ISI) to classify the level of damage. Additionally, it detects nutrient deficiencies like nitrogen and magnesium by examining yellow and pale green color variations. The system further enhances decision-making by recommending an appropriate pesticide spray volume based on environmental factors such as temperature, humidity, and soil moisture. By providing detailed outputs including disease type, severity level, nutrient status, and spray recommendations, PestiSense helps reduce manual effort, optimize pesticide usage, and improve overall crop productivity. Although it currently relies on basic color-based detection, it serves as an effective and low-cost prototype with strong potential for future enhancements using advanced AI, IoT integration, and mobile applications.

Figure 4; prototype

Figure 5; Good Health

Smart Pesticide Spray Monitoring System

The block diagram represents the overall working structure of the smart pesticide spraying and monitoring robot system. In this system, the Arduino UNO acts as the main controller that controls all the components. The ultrasonic sensor is used to detect obstacles in the path of the robot and send signals to the controller. The motor driver (L298N) receives control signals from the Arduino and drives the DC motors for robot movement. A servo motor is used to control the direction of the spraying mechanism. The sprinkler system is responsible for spraying pesticides in the required area. The entire system is powered by a 12V battery power supply, which provides the necessary energy to all components. Together, these components work to perform automatic pesticide spraying and obstacle detection efficiently.

Block Diagram

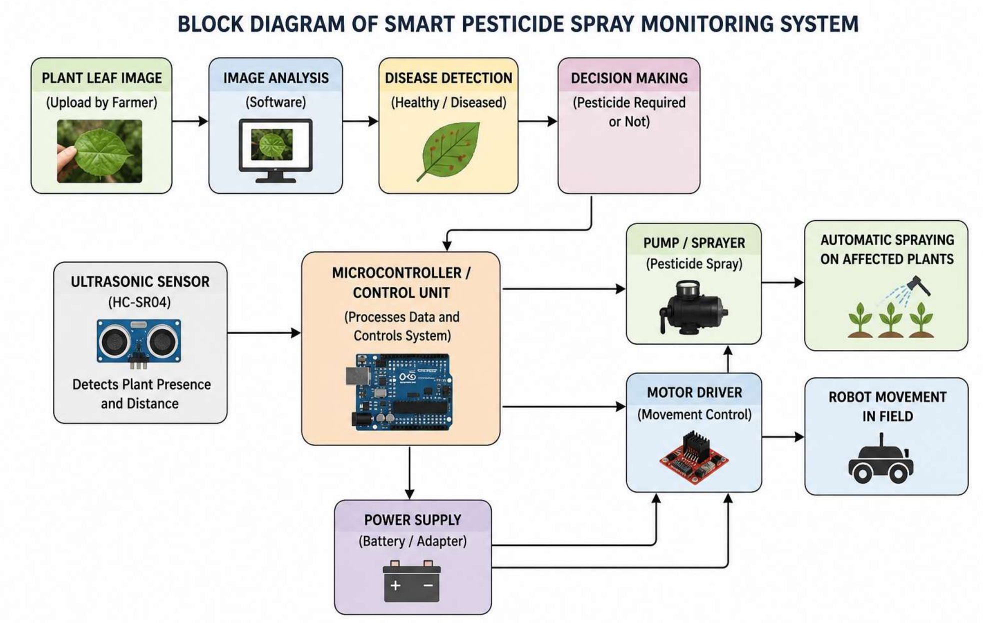

Figure 4.2.1 Block Diagram

Figure 6; Block Diagram

Power Supply (12V Battery)

The power supply provides electrical energy to the entire system. A 12V battery is used to power the Arduino, motor driver, sensors, and other components. It ensures proper functioning of all modules in the robot.

Arduino UNO (Controller)

Arduino UNO acts as the main controller of the system. It processes the signals received from sensors and sends commands to the motor driver, servo motor, and sprinkler system to control the robot's operations.

Ultrasonic Sensor

The ultrasonic sensor is used to detect obstacles in front of the robot. It measures the distance between the robot and objects and sends the information to the Arduino for further action.

Motor Driver (L298N)

The motor driver controls the speed and direction of the DC motors. It receives signals from the Arduino and provides sufficient current to drive the motors.

DC Motor (Robot Movement)

DC motors are used to move the robot. They rotate the wheels and allow the robot to move forward, backward, or change direction.

Servo Motor

The servo motor controls the direction of the spraying mechanism. It rotates to different angles to spray pesticides over the crops effectively.

Sprinkler System

The sprinkler system sprays pesticides on the plants. It helps distribute pesticides evenly and reduces manual labor in agriculture.

Working Methodology

The system works by using the Arduino Uno as the main controller, which receives distance data from the HC-SR04 Ultrasonic Sensor to detect obstacles and make real-time decisions for movement. Based on this input, the L298N Motor Driver controls the DC motors for navigation, while the servo motor adjusts the direction of pesticide spraying, and the entire system is powered by a 12V battery to ensure continuous and stable operation.

Here's an in-depth explanation of each step:

Component Integration:

All hardware modules are interconnected with the Arduino Uno. This ensures smooth communication between sensors, motors, and actuators.

Signal Transmission:

Electrical signals are transmitted from sensors to the controller efficiently. This enables accurate and timely system responses.

Obstacle Avoidance Mechanism:

The HC-SR04 Ultrasonic Sensor helps in detecting objects ahead. The system automatically adjusts movement to prevent collisions.

Speed Regulation:

The L298N Motor Driver controls motor speed based on commands. It ensures balanced and controlled movement.

Directional Control:

The robot changes direction (left/right) when obstacles are detected. This improves navigation efficiency in complex paths.

Targeted Spraying Operation:

The servo motor ensures precise spraying of pesticides. It focuses only on required crop areas to avoid wastage.

Energy Efficiency:

The 12V battery optimizes power usage across components. It supports reliable and long-term field operation.

System Stability:

The setup maintains consistent performance under different conditions. It reduces chances of system failure.

User Convenience:

The automated design reduces human effort. It makes the system easy to operate and maintain.

Scalability:

The system can be upgraded with additional sensors or modules. This allows future improvements and advanced features.

Results and Discussion

Results

The system successfully demonstrates an efficient smart pesticide spray monitoring setup using Arduino Uno, L298N Motor Driver, DC motors, a servo motor, and an ultrasonic sensor. The ultrasonic sensor accurately detects obstacles and distance, allowing the robot to move safely in the field. The motor driver controls the movement of wheels, while the servo motor enables precise spraying direction. The use of a 12V battery ensures stable power supply to all components. Overall, the system provides reliable automation, reduces manual effort, and improves efficiency in pesticide spraying operations.

Key aspects of the results include:

Efficient System Control: The Arduino Uno ensures smooth coordination of all components. It processes inputs and controls outputs effectively for reliable operation

Accurate Obstacle Detection: The HC-SR04 Ultrasonic Sensor detects obstacles with high accuracy. This helps the robot move safely without collisions.

Smooth Motor Operation: The L298N Motor Driver enables efficient control of DC motors. It provides stable and controlled movement across the field.

Precise Spraying Mechanism: The servo motor ensures targeted pesticide spraying. It reduces chemical wastage and improves spraying efficiency.

Reliable Power Supply: The 12V battery provides consistent power to all components. It supports uninterrupted system operation.

Reduced Manual Effort and Increased Efficiency: The system minimizes human involvement in spraying tasks. It saves time, improves productivity, and enhances safety.

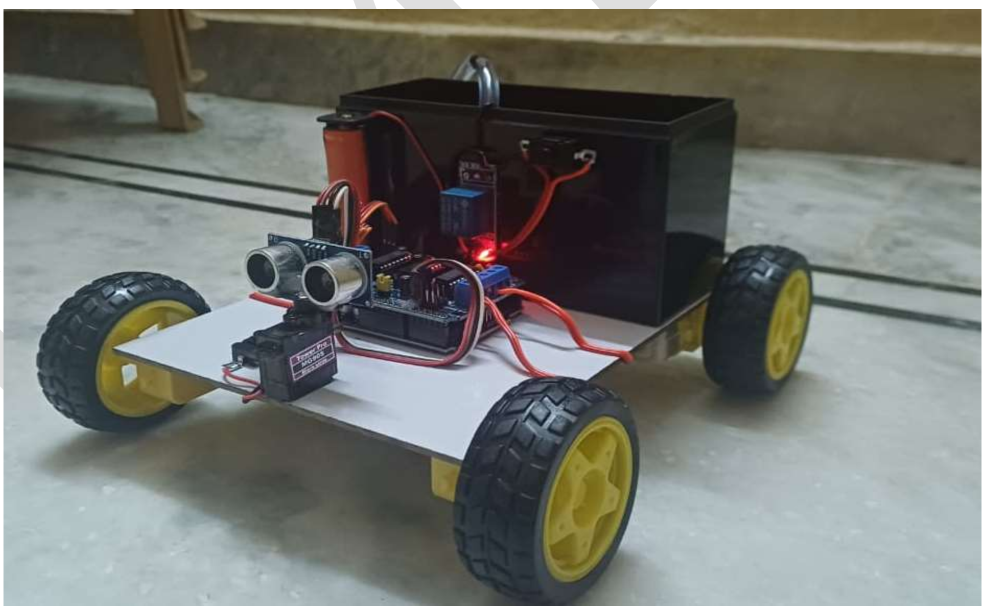

Figure 7; Hardware Setup

This image shows a basic DIY four-wheeled robotic car, likely designed for electronics or robotics projects. The car chassis is simple, with a white base supporting four yellow wheels, each attached to a small motor for movement. On top of the chassis, there is an Arduino motor driver shield connected via wires to control the motors. A servo motor is also mounted at the front, which could be used for steering or moving a sensor. At the back, a black box likely houses the battery pack that powers the motors and electronics. Additionally, there is an ultrasonic sensor attached near the servo, which is used for obstacle detection, making the robot capable of basic autonomous navigation. Overall, this setup is typical for a beginner's obstacle-avoiding or line-following robot project.

Discussion

The implementation and testing of the system in a real-time setup, as shown in the image, demonstrate its practical feasibility and effective integration of both hardware and control mechanisms. The arrangement of components, including the Arduino Uno, L298N Motor Driver, motors, and wiring, reflects a compact and organized design suitable for field deployment. The highlighted section indicates proper electrical connections and secure placement of components, which are essential for stable operation. The system successfully responds to sensor inputs from the HC-SR04 Ultrasonic Sensor, enabling accurate obstacle detection and smooth navigation.

Additionally, the integration of actuators such as DC motors and a servo motor ensures controlled movement and precise pesticide spraying. The real-time results confirm that the system operates efficiently with minimal signal loss or power fluctuation, supported by a stable battery supply. Overall, the practical setup validates the reliability, robustness, and usability of the system in agricultural environments, while also highlighting its potential for further improvements in wiring optimization, component protection, and large-scale implementation.

Conclusion

The developed Smart Pesticide Spray Monitoring System demonstrates the effective integration of electronic components to automate pesticide spraying in agricultural fields. The system is built around the Arduino Uno, which serves as the central controller for processing sensor inputs and controlling the overall operation of the robot. An ultrasonic sensor is used to detect obstacles and maintain a safe distance during movement, while a motor driver controls the DC motors that enable the robot to navigate across the field. A servo motor operates the pesticide spraying mechanism, ensuring accurate and controlled spraying. The entire system is powered by a rechargeable battery, making it suitable for outdoor agricultural applications. The successful implementation of the system shows that it can perform automatic pesticide spraying efficiently, reduce the need for manual labor, minimize human exposure to harmful chemicals, and improve the overall effectiveness of crop protection. The project demonstrates that a simple combination of sensors, controllers, and actuators can provide a reliable, cost-effective, and intelligent solution for modern agricultural practices.

Future Scope

The Smart Pesticide Spray Monitoring System offers significant opportunities for future enhancement to improve its efficiency, accuracy, and applicability in precision agriculture. A camera module can be integrated to monitor crop conditions and detect plant diseases in real time using image processing techniques. The addition of GPS technology would enable autonomous navigation in large agricultural fields, allowing the robot to operate without manual guidance. Wireless communication technologies such as Wi-Fi or Bluetooth can be incorporated to facilitate remote monitoring and control of the system through smartphones or computers. To improve energy efficiency and support long-duration field operations, solar panels can be integrated as an alternative power source. Furthermore, advanced sensors for measuring soil moisture, temperature, and humidity can be included to provide valuable environmental data for better crop management and decision-making.

The system can also be upgraded by replacing the Arduino Uno with a more powerful microcontroller or embedded computing platform to support advanced processing capabilities and additional functionalities. Artificial intelligence and machine learning algorithms can be incorporated to automatically identify crop diseases, estimate their severity, and determine the optimal quantity of pesticide required, thereby reducing chemical wastage and improving crop health. The spraying mechanism can be further refined to ensure more uniform and precise pesticide distribution across plants. In addition, the robot's mechanical design can be enhanced to operate efficiently over larger agricultural areas and different types of terrain. Future versions of the system can also be expanded to perform multiple agricultural tasks, including fertilizer spraying, crop monitoring, field surveillance, and data collection, making it a comprehensive smart farming solution that supports sustainable and efficient agricultural practices.

References

[1] V. Vijayakumar, A. de Oliveira Costa Neto, Y. Ampatzidis, J. Schueller, W. S. Lee, and T. Burks, "Design and Evaluation of a PI-Controlled Robotic Smart Sprayer for Precision Herbicide Applications with Multi-Nozzle Integration," *Precision Agriculture*, vol. 27, no. 1, pp. 1–12, 2026.

[2] S. M. Hossain, A. Ghosh, S. Mondal, S. Ghosh, A. Mondal, and A. Bhattacharya, "IoT-Based Drone for Smart Farming," in *Intelligent Systems in Solid-State Electronics and Communication Engineering*, pp. 39–47, 2026.

[3] B. Thanuja, D. Jatin Kumar, S. S. Srinivas, M. S. Hussain, and S. I. Hussain, "LiFi Based Underwater Communication," *International Journal of Modern Engineering and Technology Science (IJMETS)*, vol. 6, no. 4, pp. 1366–1373, 2024.

[4] J. A. Thomasson, R. Sui, V. Salas, and J. D. Pugh, "A Review of Sensor-Based Technologies for Precision Agriculture," *Computers and Electronics in Agriculture*, vol. 162, pp. 1043–1055, 2019.

[5] Q. Zhang and F. J. Pierce, *Agricultural Automation: Fundamentals and Practices*. Boca Raton, FL, USA: CRC Press, 2013.

[6] H. M. ElSayed, M. A. Abdelrahman, and A. E. Hassanien, "Internet of Things Applications in Smart Agriculture: A Survey," *IEEE Access*, vol. 8, pp. 181747–181768, 2020.

[7] S. Wolfert, L. Ge, C. Verdouw, and M. J. Bogaardt, "Big Data in Smart Farming—A Review," *Agricultural Systems*, vol. 153, pp. 69–80, 2017.

[8] Arduino, *Arduino Uno Rev3 Technical Specifications*. Arduino AG, 2024.

[9] D. Patranabis, *Sensors and Transducers*, 3rd ed. New Delhi, India: PHI Learning, 2018.

[10] L. Jawad, R. K. Mahmud, and A. H. Ahmed, "Design and Development of an Autonomous Agricultural Spraying Robot Using Arduino and Ultrasonic Sensors," *International Journal of Advanced Computer Science and Applications (IJACSA)*, vol. 12, no. 8, pp. 512–519, 2021.