American International University-Bangladesh (AIUB)
Faculty of Engineering (FE)
Department of Electrical and Electronic Engineering (EEE)

Course Name:	Microprocessor and Embedded Systems	**Course Code:**	EEE 4103
Semester:	Spring 2024-2025	**Section:**	R
Faculty Name:	**Prof. Dr. Engr. Muhibul Haque Bhuyan**		

Capstone Project Title:	Arduino Based Remote-Controlled Pesticide Sprayer Car
Project Group #:	5

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Assessment Materials and Marks Allocation:

CO/ CLO Number	CO/CLO Statement	K	P	A	Assessed Program Outcome Indicator	BNQF Indicator	Teaching-Learning Strategy	Assessment Strategy
3	**Demonstrate** a course project using microcontrollers, sensors, actuators, switches, display devices, etc. that can solve a complex engineering problem in the electrical and electronic engineering discipline through appropriate research.	**K8**	**P1 P3 P7**		**P.d.1.P3**	**FS.3**	**Discussion**	**Project Report (Literature Review)**
4	**Explain** the complex engineering activities of a course project solving a complex engineering problem of the electrical and electronic engineering discipline through an effective presentation.			**A1 A2**	**P.j.3.A4**	**SS.2**	**Discussion**	**Project Presentation**

Assessment Rubrics:

COs	Excellent to Proficient [5-4]	Good [3]	Acceptable [2]	Unacceptable [1]	No Response [0]	Secured Marks
CO3 P.d.1.P3	The outcome of the project demonstrates a course project utilizing microcontrollers, sensors, actuators, switches, display devices, and more, which can address a complex engineering problem in the electrical and electronic engineering field through appropriate research.	The outcome of the project demonstrates a course project utilizing microcontrollers, sensors, actuators, switches, display devices, etc., and also addresses a complex engineering problem in the electrical and electronic engineering discipline through research.	The outcome of the project demonstrates a course project using microcontrollers, sensors, actuators, switches, display devices, etc. but cannot solve a complex engineering problem properly in the electrical and electronic engineering discipline through appropriate research.	The outcome of the project does not demonstrate a course project using microcontrollers, sensors, actuators, switches, display devices, etc. It also could not solve a complex engineering problem in the electrical and electronic engineering discipline through appropriate research.	No Response at all/copied from others/ identical submissions with gross errors/image file printed	
Comments					**Total Marks (5)**	

Remote-Controlled Pesticide Spraying and Field Assistance Car for Farmers Using Arduino

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Abstract**—** This project shows the design and implementation of an Arduino-based remote-controlled pesticide sprayer car intended to increase safety and efficiency in agricultural practices. The car is built using an Arduino ESP32 microcontroller, interfaced with an L298N motor driver for directional control and a relay-based pump mechanism for pesticide spraying. Controlled via Bluetooth through a mobile phone, the vehicle allows farmers to remotely navigate the field and apply pesticides without direct exposure to harmful chemicals. The code for the car is written using the Arduino IDE, while simulations are performed in Proteus to validate system performance. This approach enables precise, targeted pesticide application, minimizes health risks, reduces chemical overuse, and supports environmentally responsible farming. Furthermore, the system utilizes cost-effective components, making it suitable for small-scale agricultural operations in rural areas with limited access to advanced technologies.

Index Terms**—** Arduino ESP32, Bluetooth Communication, Embedded Systems, Precision Agriculture, Pesticide Sprayer, Remote Control.

I. Introduction

Traditional pesticide application methods expose farmers to significant health problems, including breathing issues, skin harm, and even more. One study reports that approximately 98% of sprayed pesticides impact non-target organisms and contaminate soil and water, ultimately leading to bioaccumulation and biodiversity loss [1]. Another review highlights how pesticides can cause a range of toxic effects in humans, including neurotoxicity, carcinogenicity, and endocrine disruption, depending on the active compounds and exposure levels [2]. In addition, pesticide exposure has been linked to genetic mutations, asthma, and other long-term health effects, especially in populations with poor protective measures and low awareness [3]. Pesticides also negatively affect soil ecosystems by altering microbial and enzyme activity, which plays a vital role in maintaining soil health and fertility [4]. Even after the technological improvements, manual spraying is still common in many regions,which not only endangers human health but also the environment. To reduce these effects, the project aims to design and implement an Arduino-based, Bluetooth-controlled pesticide sprayer vehicle to minimize direct human contact with chemicals and improve spraying efficiency while costing less than existing sprayer systems. The system is intended to provide a scalable solution especially beneficial for small-scale farmers. The report begins with a literature review on the health and environmental risks associated with traditional pesticide use, followed by the proposed system's methodology, including hardware and software components. It then details the implementation and simulation processes using Arduino IDE and Proteus, and concludes with a discussion on results, impact, and potential for future development in sustainable agriculture.

II. Literature Review

Research presented an IoT-based pesticide spraying robot that offers user-controlled directional movement and spraying functionality [5]. While that system introduces flexibility in real-time operation, it lacks integration with environmental or obstacle-detection sensors. This limitation affects adaptability to uneven terrain or structured crop rows, which is critical for field efficiency and automation in diverse agricultural conditions.

Another study proposed a multifunctional robot capable of pesticide spraying and mowing, powered by solar energy and remote control [6]. The design features a 4-degree-of-freedom mechanism, providing precision and multifunctionality. However, the complexity introduced by combining two distinct agricultural functions increases mechanical and control system costs, which makes it less practical for small-scale farmers looking for simple and affordable solutions.

A research work introduced a greenhouse-targeted telerobotic pesticide applicator using ultrasonic sensors to perform foliage-based spraying [7]. Their system reduces chemical usage by 24.95% and enhances operator safety by eliminating direct chemical exposure. Despite these advantages, the system's real-time video feedback, wireless control, and complex sensor integration make it costly and difficult to maintain, especially outside controlled environments like greenhouses.

A study developed a solar-powered pesticide spraying vehicle controlled via an HC-05 Bluetooth module and ATMEGA32A microcontroller[8]. It effectively reduces manual labor and exposure risks, aligning with safety goals. However, it depends heavily on solar charging, which restricts its scalability and effectiveness in varying weather conditions.

Another study proposed a self-propelled, remote-controlled pesticide sprayer focused on reducing manual labor and improving application accuracy [9]. While the concept is promising, the paper lacks specific implementation details such as power source, spraying mechanisms, and sensor feedback, limiting its applicability as a complete, deployable solution.

The studies show the increasing trend toward automation in agriculture, but many suffer from limitations such as high cost, mechanical complexity, or lack of adaptability to field conditions. In contrast, this project seeks to develop a simple, cost-effective, and Bluetooth-controlled pesticide sprayer using ESP32, which addresses both the health risks of manual spraying and the need for affordability and ease of use in small-scale farming.

III. Methodology and Modeling

Some of the core operational features of the proposed system include the ability to remotely navigate the pesticide sprayer vehicle and activate spraying mechanisms in real time using a Bluetooth-based mobile control interface. The system is built around the ESP32 microcontroller, which acts as the central control unit for processing motor and spray commands. Key components include the L298N motor driver for controlling the forward, backward, left, and right motion of the vehicle through two DC motors, and a relay module that switches the pesticide pump on or off based on received instructions. The vehicle's movement and spraying logic are programmed using the Arduino IDE, enabling precise control and responsiveness during operation. Bluetooth communication between the ESP32 and the mobile phone is established using a serial interface, allowing farmers to issue movement and spray commands via a compatible mobile app. This real-time remote operation helps reduce direct exposure to hazardous chemicals and enhances the efficiency of pesticide application. This system is most appropriate for small-scale farmers in rural areas where manual spraying still prevails, offering them a safer, cost-effective, and user-friendly alternative with minimal learning curve.

A. Description of The Components Used

ESP32 Microcontroller:

The ESP32 is a low-cost, high-performance microcontroller with integrated Bluetooth and Wi-Fi. In this project, it serves as the central control unit, receiving commands from a mobile device and controlling the vehicle's movement and spraying operations in real time.

Fig. 1. ESP32

L298N Motor Driver Module:

This dual H-Bridge motor driver is used to control the rotation of two pairs of DC motors. It interprets the signals from the ESP32 to regulate the direction and movement of the vehicle efficiently.

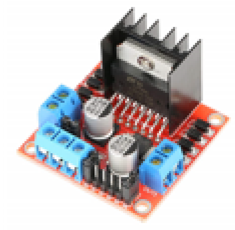

Fig. 2. L298N

DC Motors and Wheels(4 Units)

DC motors and wheels are used two for each side of the vehicle to ensure balanced and stable navigation. These motors allow the vehicle to move forward, backward, and turn with more torque and reliability, especially on uneven terrain.

Fig. 3. DC Motors and Wheels

Relay Module

The relay module is used to control the pesticide pump. It acts as a switch that is triggered by the ESP32 to start or stop the spraying process.

Fig. 4. Relay Module

DC Pump

An electric pump is used to spray the pesticide stored in an onboard tank. When activated by the relay, it pushes the fluid through a nozzle to apply pesticides over crops.

Fig. 5. DC Pump

LiPo Battery (Rechargeable)

A rechargeable battery pack powers the entire system, including the ESP32, DC motors, and pump.

Fig. 6. LiPo Battery

Buck Converter

Buck converter changes the voltage flow from the battery efficiently throughout the system.

Fig. 7. Buck Converter

B. Working Principle of the Project

The block diagram presented in Fig. 8 shows the process of the project where the project is operated using an ESP32 microcontroller that receives commands via Bluetooth from a mobile phone app. These commands control four DC motors through an L298N motor driver for directional movement. A relay module is used to activate the pesticide pump when a spray command is issued. ESP32 processes these actions in real time, ensuring smooth navigation and spraying. The entire system is programmed using Arduino IDE and controlled with a Bluetooth car controller app.

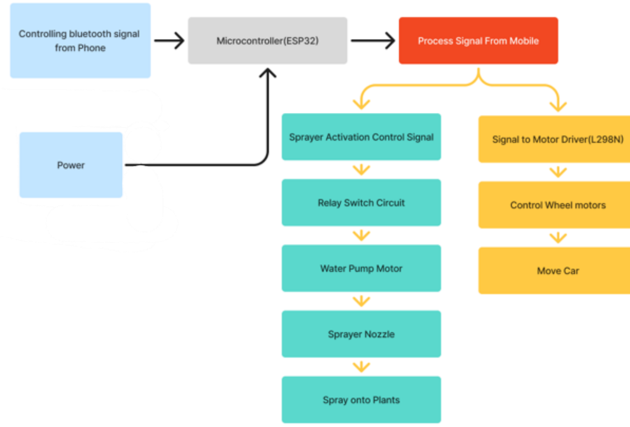

Fig. 8. Block Diagram of the process

C. Flowchart

The flowchart shown in Fig. 9. illustrates the operation of the Bluetooth-controlled agricultural spraying robot. The system initiates by configuring essential components, including the serial communication interface, bluetooth connection, and motor control pins, ensuring it is fully prepared to receive and execute user inputs. Then, the robot stays in an idle state where all functionalities remain off. This initial OFF state serves as a safety mechanism to prevent unintended movement or spraying upon startup. If the command is for spraying, the robot activates the sprayer for two seconds. If the input is for movement, the robot responds by moving in the indicated direction of forward, backward, left, or right, which allows manual navigation. After executing the specified actions, the robot returns to the idle state and waits for further input. This loop operates continuously, enabling real-time and flexible control in dynamic agricultural conditions.

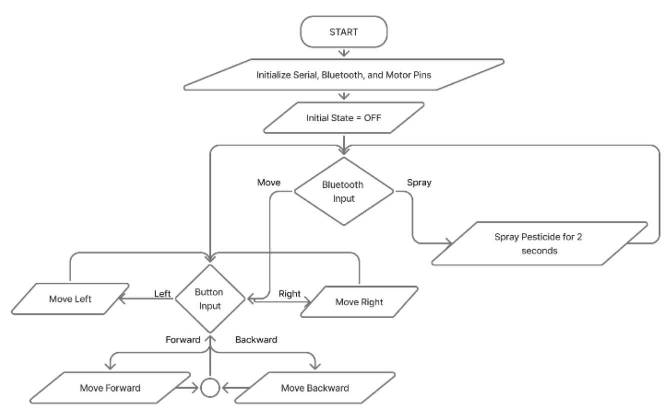

Fig. 9. Flowchart of the process

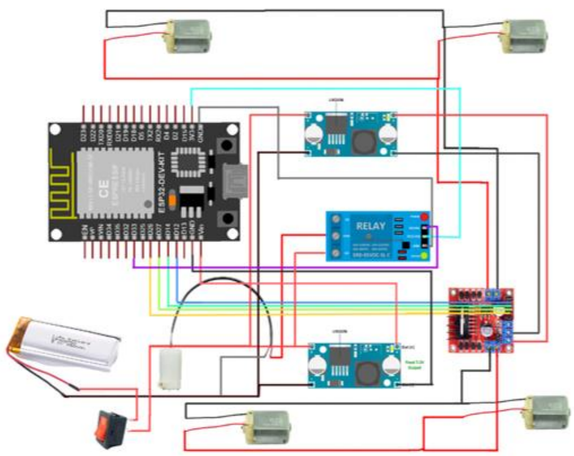

Fig. 10. Schematic Diagram of the project

IV. COST ANALYSIS

To assess the cost of the proposed Bluetooth-controlled pesticide sprayer car, Table I provides the cost of the project and a comparison with similar options currently available in the market, including RC-controlled, electric, and battery-powered sprayers is shown. This comparison highlights the affordability and practical advantages of our proposed solution.

TABLE I
COST ANALYSIS OF THE PROJECT

No.	Product	Quantity	Subtotal (BDT)
1	ESP32	1	600
2	L298N Motor Driver	1	160
3	LM2596 Buck Converter	2	180
4	Tape	1	20
5	Female Header	1	30
6	Switch	1	10
7	Yellow Motor + Wheel	4	680
8	1 Channel 5V Relay Module	1	95
9	Female to Female Jumper Wires (20 pcs, 20cm)	1	55
10	LiPo Battery 1500mAh 7.4V 2S+ Charger	1	1,300+445=1,745
11	Submersible 3V Mini DC Water Pump	1	120
12	Twisted Electrical Flexible Wire - Red & Black (1m)	2	90
	Total		3,785

TABLE II
COST COMPARISON OF THE PROJECT

Product Name	Type	Cost (BDT)
Project	RC-controlled sprayer	**3,785**
RC Metal Car (1/18 Scale)	RC base car	1,750
Double Gun Power Spray Machine	Sprayer	32,500
Sulov Battery Sprayer	Battery sprayer	4,534
Battery Operated Sprayer (16L)	Battery sprayer	3,800

V. SIMULATION AND RESULT

HARDWARE:

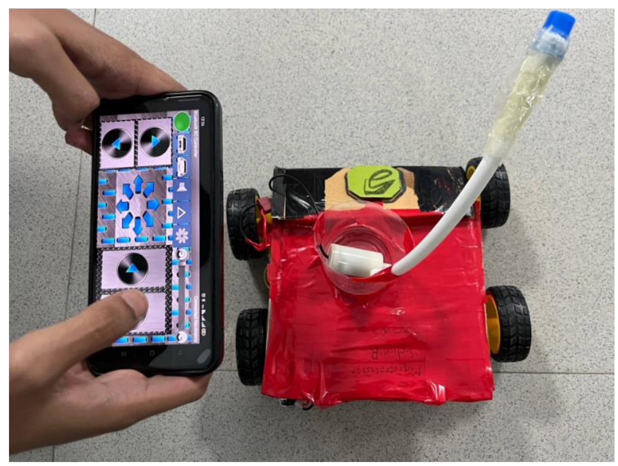

Fig 11. Controlling The Car Using Bluetooth Controller App

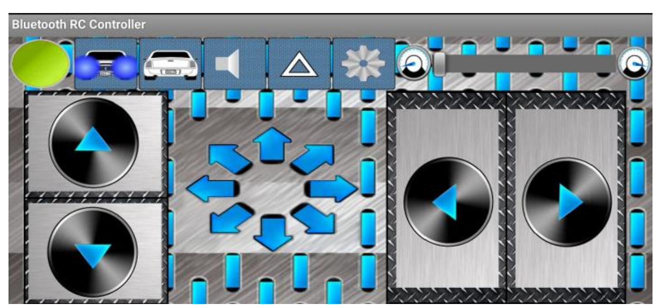

Fig 12. Bluetooth App Pump-On Input

Fig 13. Bluetooth App Pump On Output

Fig 14. Bluetooth App Forward Input-Output

Fig. 15. Bluetooth App Backward Input-Output

Fig. 16. Bluetooth App Left Input-Output

Fig. 17. Bluetooth App Right Input-Output

SOFTWARE SIMULATION:

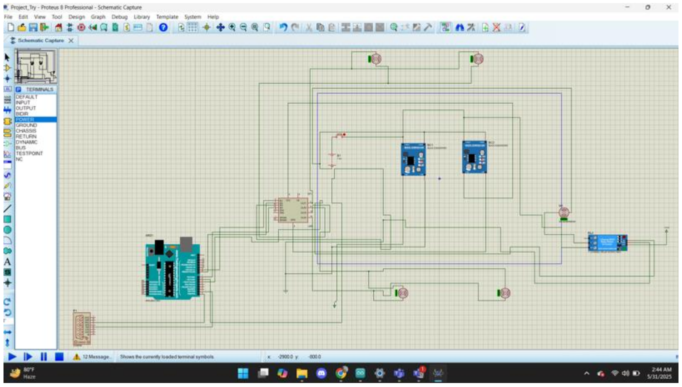

Fig. 18. Schematic in Proteus

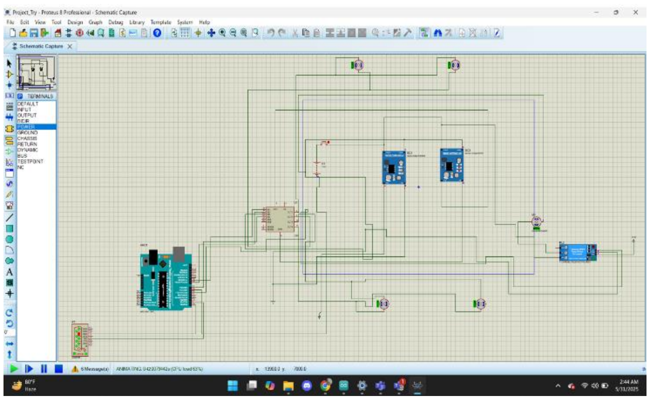

Fig. 19. Input to Project Simulation(COMPIM RED)

Table III shows the output of the project with the Bluetooth app input. The robot goes to the direction according to the user input. The pump needs minimum of around 40 mL water or pesticide in the jar to spray, as seen on the table below. The highest amount of water sprayed is around 44 mL.

TABLE III
INPUT AND OUTPUT THE PROJECT

Initial	Input	Output
Idle	Forward	Goes Forward
Idle	Backward	Goes Backward
Idle	Left	Goes Left
Idle	Right	Goes Right
Idle with 120ml Water	Pump On	44ml Water Spray for 2 seconds
Idle with 76ml Water	Pump On	42ml Water Spray for 2 seconds
Idle with 34ml Water	Pump On	No Spray, only pump turns on

F. Comparison between Software and Hardware simulation:

The simulation did not perfectly work, as all the required components were not found in the software, the ESP32 was replaced by Arduino Uno and HC-05. The motors did not receive the input properly, so the motors did not move. In hardware simulation the bluetooth signal from the phone app was received by the ESP32 and then the car moved as per the user input. Finally, the pump button in the bluetooth app was pressed to spray water. So, only the hardware simulation worked perfectly, but not the software simulation.

G. Limitations of this project:

Spraying requires the vehicle to move slowly, which reduces overall efficiency, and the small spray tank is limited by the short pump wire which restricts continuous usage time. As a result, this system is best suited for small plots and is not ideal for larger farms without further upgrades.

H. Future Scope

To advance the system's capabilities, autonomous navigation can be implemented using GPS or sensor-based path planning, enabling fully automated pesticide spraying without the need for manual control. This would ensure more precise and efficient coverage across fields. Additionally, upgrading to a larger spray tank and a more powerful pump would allow the system to support larger agricultural areas with fewer refills. Integrating an app-based interface to track spray coverage, battery usage, and overall performance would further optimize operations and provide valuable data for future improvements.

V. Conclusion

This project successfully developed a simple and affordable remote-controlled pesticide sprayer car using an Arduino ESP32, designed to make pesticide application safer and more efficient for farmers. By controlling the vehicle and spraying through a Bluetooth connection on a mobile phone, farmers can avoid direct contact with harmful chemicals while precisely navigating their fields. The use of low-cost, readily available parts means this system is especially helpful for small-scale farmers in rural areas who may not have access to advanced equipment. While the hardware worked well in testing, some challenges were faced in the software simulation due to missing components. The current design is best suited for smaller farms because of the limited spray tank size and the need to move slowly while spraying. However, the project lays important groundwork for improving safety and reducing chemical waste in farming. Overall, this project offers a practical step toward healthier, more environmentally friendly, simple and accessible farming through technology.

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