ROBOTIC UTILITY VEHICLE

A MINI PROJECT

Submitted by

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Mini Project Report Cover Sheet

Title of the Project : Robotic Utility vehicle

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Particulars	Max. Marks	S SHANIL RA2211004010 577
Problem Understanding & Objective	5	
Methodology/Algorithm/ Design Approach	15	
Implementation / Experimental Work	15	
Testing & Analysis	5	
Presentation & Viva	5	
Report	5	
Total	50	

Lab Instructor: Dr.S. Shayna Kumari

ABSTRACT

This project presents the development of a multifunctional robotic utility vehicle designed for remote operations in complex environments. The system integrates two ESP32-based microcontrollers to enable autonomous communication and control. An ESP32-CAM module is used to establish a dedicated Wi-Fi access point (SSID: "UTILITY CAR") for hosting a web-based control user interface and providing real-time video streaming. The second microcontroller, an ESP32-Wrover, is responsible for handling vehicle movement and precise control of a 4-degree-of-freedom robotic arm. Communication between the two modules is facilitated by ESP-NOW, a lightweight and efficient wireless protocol ideal for low-latency control tasks.

The vehicle chassis features a 4x4 drive system capable of navigating uneven terrains, making it suitable for outdoor or rough-environment exploration. The robotic arm is designed for basic pick-and-place tasks and can be used for manipulating objects in hazardous or hard-to-reach locations. The web interface allows for simultaneous control of both driving and arm functions, making the system intuitive and user-friendly.

Applications of this system include search and rescue, remote inspections, hazardous material handling, and educational demonstrations in embedded systems and robotics. Future improvements may include autonomous navigation using onboard sensors, object recognition using machine learning, and solar power integration for extended field deployment.

ACKNOWLEDGEMENTS

We would like to express our heartfelt gratitude to all those who contributed to the successful completion of this project on **ROBOTIC UTILITY VEHICLE**

First and foremost, we are deeply thankful to our project supervisor, Dr.Shayna Kumari for their invaluable guidance, consistent support, and constructive feedback throughout the course of this work. Their expertise and encouragement greatly influenced the quality and direction of this project.

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Lastly, we would like to acknowledge our peers, friends, and families for their constant motivation and moral support throughout this endeavour. Their encouragement helped us stay focused and determined during the challenging phases of the project

Signature

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CHAPTER 1

INTRODUCTION

The Robotic Utility Vehicle (RUV) is a versatile, WIFI-controlled, multi-functional system designed for remote assistance, material handling, and exploratory tasks in challenging environments.

Powered by the ESP32 microcontroller, the vehicle integrates a 4-wheel drive system with an articulated robotic arm, allowing it to navigate terrain and perform precision tasks simultaneously.

At the core of the RUV lies the ESP32-CAM and ESP32-Wrover modules, which handle wireless communication and real-time control of the motors and servo-based robotic arm. The L298N motor driver controls two DC motors for vehicle movement (forward, backward, turning), while servo motors manage the robotic arm’s base, shoulder, elbow, and gripper functions.

The entire system is wirelessly operated using a Bluetooth interface, offering easy and responsive control through a mobile device or computer. Whether navigating narrow passages or picking up objects, the RUV is an ideal platform for tasks in hazardous or remote environments such as warehouses, rescue zones, or research labs.

This project demonstrates a compact integration of mobility, manipulation, and wireless communication, making it a valuable prototype for educational, industrial, and assistive robotic applications.

CHAPTER 2

PROBLEM STATEMENT

In environments where human access is limited, hazardous, or inefficient—such as disaster zones, industrial sites, or confined spaces—there is a growing need for a compact, versatile, and remotely operable robotic system that can both navigate and manipulate objects. Existing robotic systems are often either too specialized, expensive, or lack modular control, making them impractical for flexible, real-world use cases.

The problem, therefore, is to design and implement a low-cost, WIFI-controlled robotic utility vehicle that is capable of both autonomous movement and mechanical manipulation via a servo-actuated robotic arm. The vehicle must be controllable through wireless communication, capable of executing directional commands (forward, reverse, left, right), and performing arm-based operations such as lifting, grabbing, and placing objects.

The solution should integrate core components like ESP32 microcontrollers, DC motors with L298N motor drivers, and servo motors, while maintaining power efficiency, structural integrity, and user-friendly interface options. This robotic utility vehicle will serve as a functional prototype for applications in rescue operations, warehouse logistics, and educational robotics.

CHAPTER 3

OBJECTIVES

1. To design and develop a WIFI-controlled robotic vehicle capable of remote operation.

2. To implement a 4-wheel drive system using DC motors and an L298N motor driver for directional movement.

3. To integrate an ESP32 microcontroller for wireless communication and real-time control.

4. To construct a servo-driven robotic arm with multiple degrees of freedom for object manipulation

5. To ensure smooth coordination between vehicle motion .

6. To create a user-friendly control interface accessible via WIFI from a mobile device or PC.

7. To keep the system cost-effective, compact, and suitable for real-world applications like rescue, warehousing, or field research

CHAPTER 4

SYSTEM DIAGRAM AND DESCRIPTION

4.1 Project Components / Modules

1. L298N Motor Driver[Fig.1]: A dual H-Bridge motor driver used to control the speed and direction of DC motors and stepper motors.

2. ESP32-S Microcontroller[Fig.2]: A powerful microcontroller with built-in Wi-Fi and Bluetooth for controlling devices and processing data.

3. Servo Motors[Fig.3]: Motors that provide precise control of angular position, commonly used in robotics for movement control.

4. DC Motors[Fig.4]: Motors that convert electrical energy into mechanical motion, commonly used for continuous rotation applications.

5. LM2595 Step-Down Power Module[Fig.5]: A buck converter used to step down higher input voltages to a stable, lower voltage for powering electronics.

6. 18650 Lithium Batteries[Fig.6]: Rechargeable batteries commonly used in high-energy applications like robotics, providing power to the system.

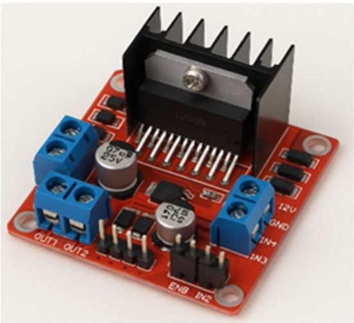


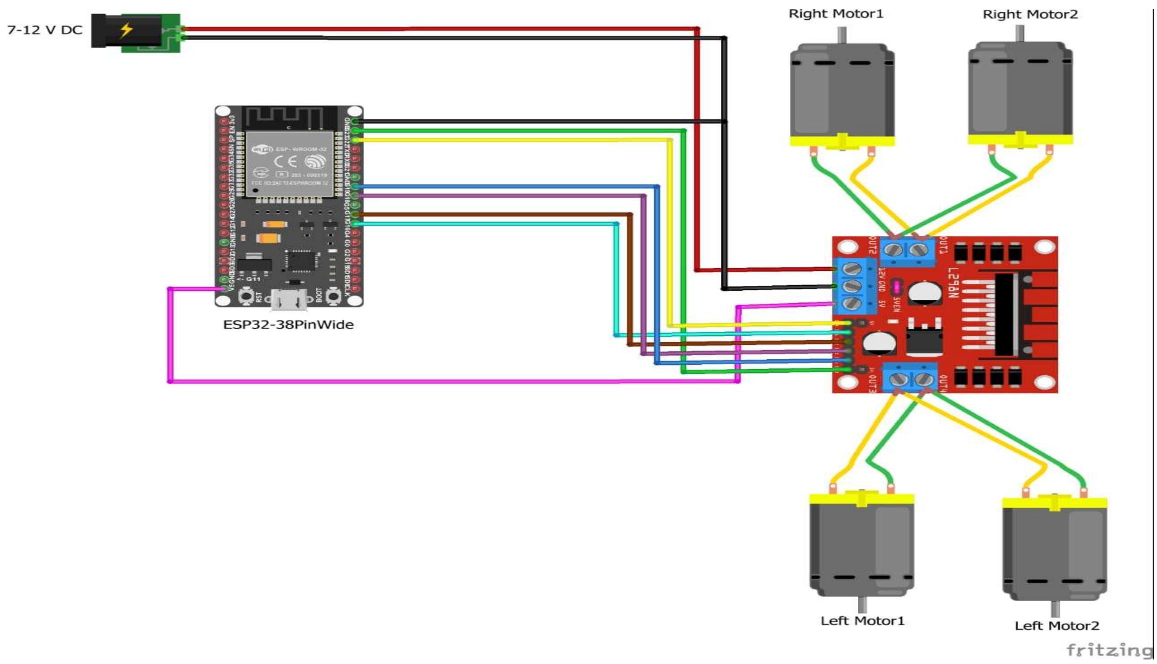
Fig 1. L298N Motor Driver 2. ESP32-S Microcontroller

3. DC motors

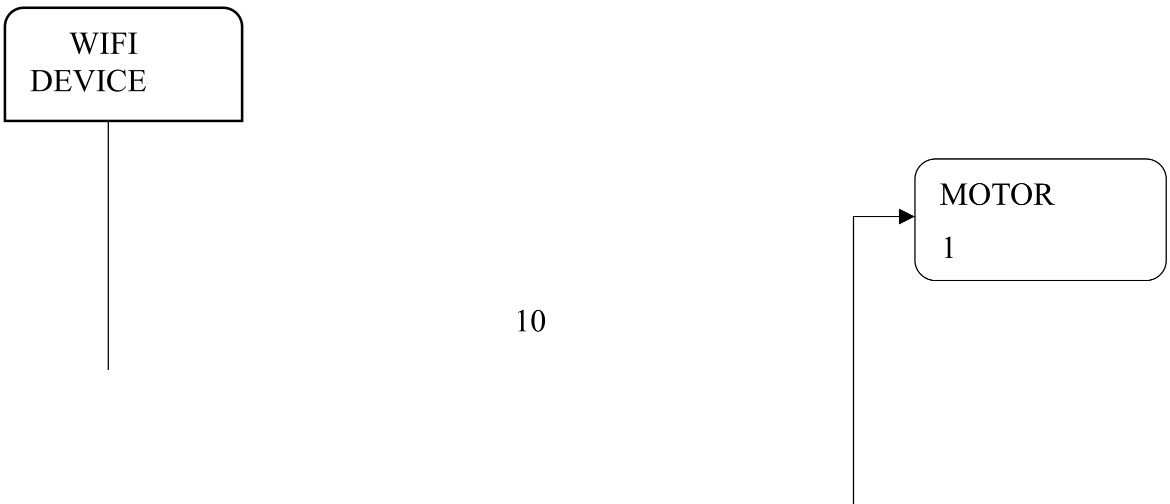
4. Lithium batteries

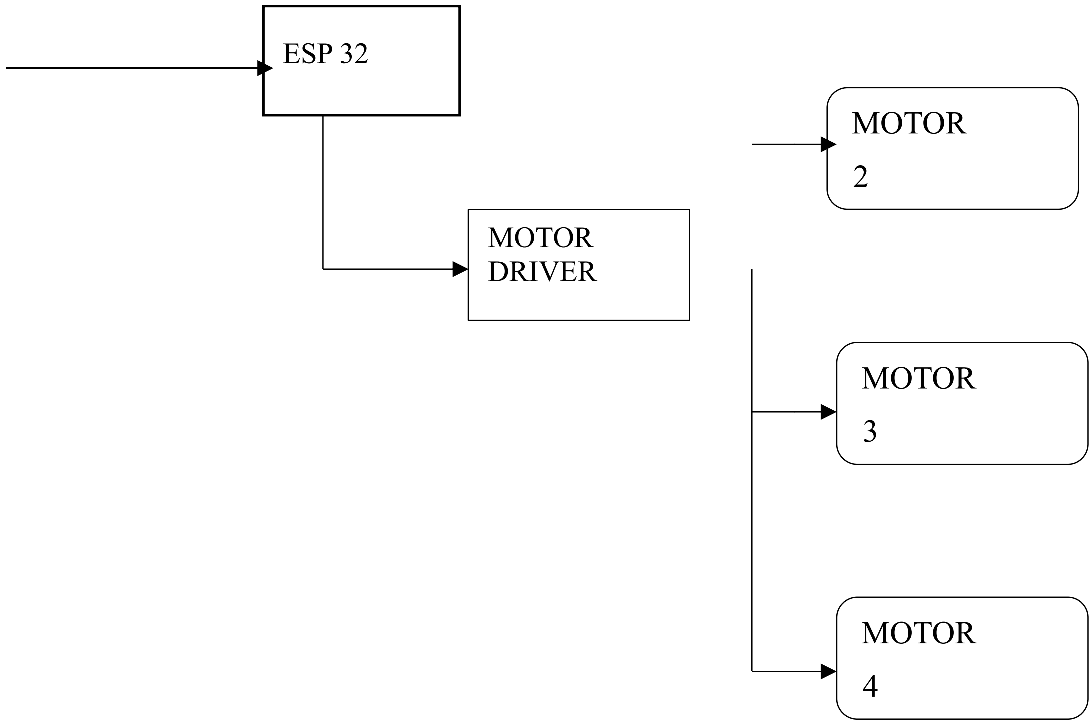
4.2 Circuit

Fig.7.Connection Diagram:



Block Diagram:





CHAPTER 5
METHODOLOGY AND IMPLEMENTATION

The methodology focuses on Developing this robotic utility vehicle employs a modular and iterative methodology. The process begins by breaking down the vehicle's desired functions into manageable modules, such as movement control and power distribution. Each individual component, including the ESP32 microcontroller, L298N motor driver, motors, and power supply, undergoes thorough individual testing to ensure proper operation. Subsequently, these components are integrated step-by-step into functional subsystems. A robust chassis is designed and assembled to provide a stable physical platform for all the electronics and mechanical parts.

The software for the ESP32 is developed in a modular fashion, creating distinct code sections for controlling different aspects of the vehicle's behavior. Finally, the complete robotic system undergoes a phase of iterative testing and refinement. This involves identifying and resolving any integration issues, debugging software, and optimizing both hardware and software for improved performance and reliability. This iterative approach allows for flexibility and continuous improvement throughout the development process.

5.2 Implementation:

1. L298N Motor Driver: Amplifies ESP32 signals to control the direction and speed of the DC motors.

2. ESP32-S Microcontroller: Acts as the central brain, processing instructions and sending control signals to all other components.

3. Servo Motors: Provide controlled angular motion for steering mechanisms or other articulated parts.

4. DC Motors: Deliver the primary rotational force for the vehicle's movement.

5. LM2596 Step-Down Power Module: Regulates the higher voltage from the lithium batteries to the lower voltage required by the ESP32 and other components.

6. 18650 Lithium Batteries: Supply the portable electrical power necessary for the autonomous operation of the robot.

5.3 Testing and Validation

- Bluetooth tested for stable pairing and reliable command reception.

- Motor directions (FWD/REV/LEFT/RIGHT) verified using L298N.

- Power supply checked for voltage stability under load.

- Simultaneous operation of motors and robotic arm validated.
- Full task cycle (move → pick → place) tested successfully.
- Long-duration testing done to ensure thermal and operational stability

Cost Analysis:

S.no	Components	Quantity	Cost
1.	ESP-32	1	450
2.	Lithium batteries	3	360
3.	L298N	1	350
4.	DC motors	4	400
5.	Wheels	4	120
	TOTAL COST		**1680**

CHAPTER 6

RESULTS AND DISCUSSION

The robotic utility vehicle prototype successfully handled moderate loads and performed well in controlled environments. However, it faced stability issues on uneven terrain due to the basic suspension system. The semi-autonomous navigation showed limitations in obstacle detection, and battery life was sufficient for short tasks but reduced under heavier loads. These results highlight areas for improvement, particularly in navigation, stability, and energy efficiency for future versions.

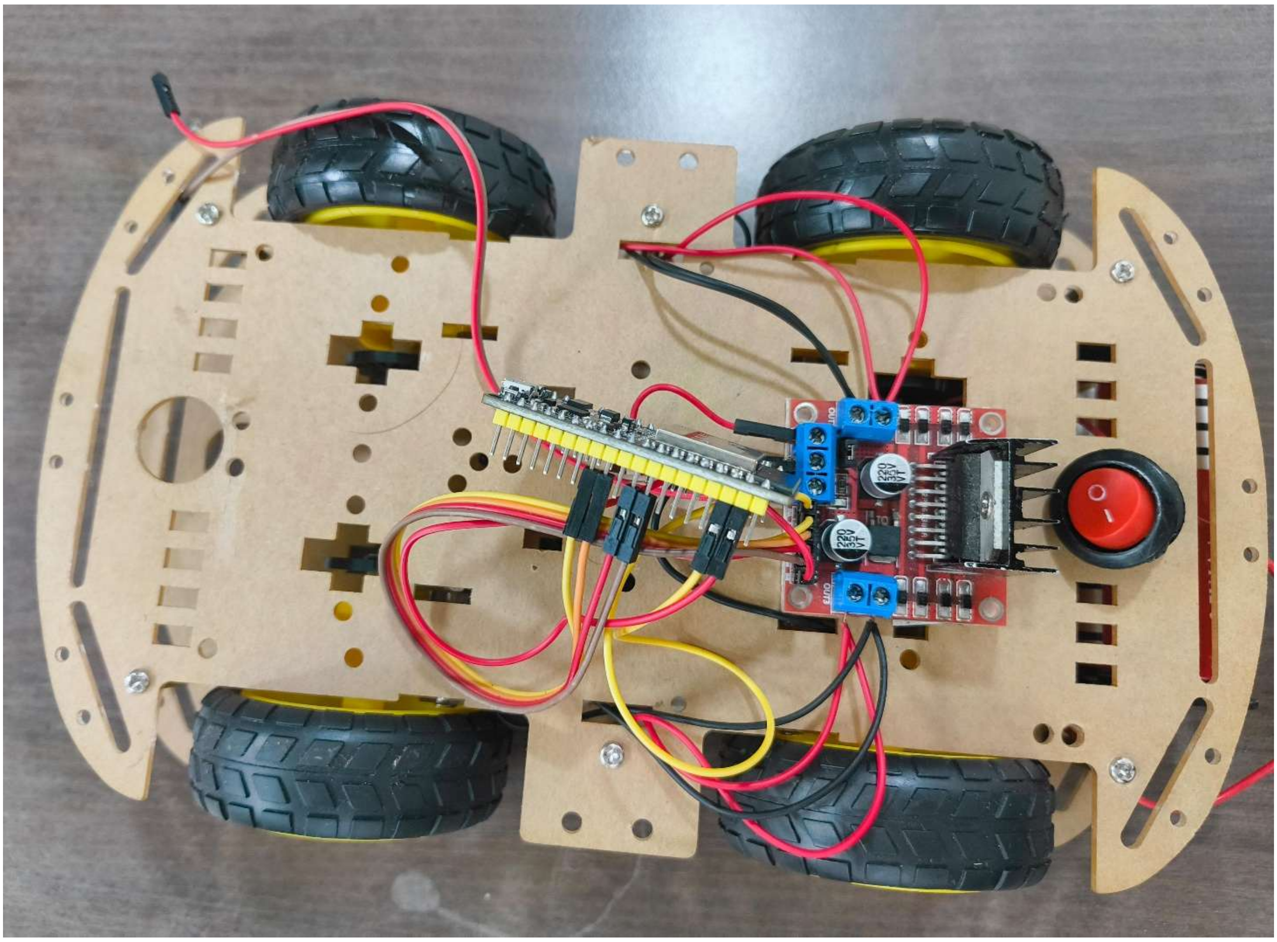


Fig.13 Demonstration

Component parameters:

Battery life: 3hrs

Voltage levels: Input voltage-12v

Speed: 10 kmph

Range: 20m

CHAPTER 7

CONCLUSION AND FUTURE WORKS

7.1 Conclusion

In this project, we successfully designed and developed a robotic utility vehicle capable of performing basic tasks with remote or autonomous control. The vehicle was built to assist in tasks like carrying loads, navigating small paths, and reducing manual effort in certain environments. Throughout the process, we learned how to integrate sensors, motors, and microcontrollers to work in coordination, ensuring smooth operation and control of the robot.

The main goal of this project was to make a utility vehicle that is both efficient and easy to use. Although there are still areas to improve, the current prototype proves the concept is practical and can be expanded for more complex use cases.

7.2 Future Works

There are several potential improvements that can be made to enhance the performance and functionality of the robotic utility vehicle. One major upgrade is the addition of autonomous navigation using GPS and path-planning algorithms, which would allow the vehicle to move without manual control. Integrating obstacle detection using sensors like ultrasonic, IR, or LIDAR can help it avoid collisions and operate more safely. To increase efficiency, the load-handling system can be improved with better motors and a stable suspension system, while solar panels can be added to support sustainable energy use. Incorporating IoT features will enable real-time monitoring and remote control via mobile apps or cloud platforms. Voice and gesture control can make the system more user-friendly, especially for those with limited mobility. Further, the use of AI or machine learning could allow the vehicle to adapt to its environment and optimize its performance over time. Additional safety features like emergency stops and fall detection can also be included for secure operation. Finally, making the vehicle modular and weather-resistant will increase its flexibility, allowing it to perform a wide range of tasks in various environments and weather conditions.

REFERENCES

[1] "A Comprehensive Study of Mobile Robot: History, Developments, Applications, and Future Research Perspectives" by Muhammad Usman et al. (MDPI, 2022):

[2] "Systematic Literature Review on Hybrid Robotic Vehicles" by Ricardoтри et al. (MDPI, 2024):

[3] "Design and control of a mobile robot following the desired Trajectory using an adaptive sliding mode approach"

[4] “AI in Autonomous Vehicles: Opportunities, Challenges, and Regulatory Implications" by Nidhi Kalra et al. (ResearchGate, 2024):

[5] "Recent Advances and Challenges in Industrial Robotics: A Systematic Review of Technological Trends and Emerging Applications" 1 by Mohammed Hadi Hussein et al. (MDPI, 2024):