2025 SPRING IOT102 Project Title

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Abstract

In the era of rapid technological advancement, the integration of smart automation and remote control into vehicular systems has become increasingly important. This project introduces a smart vehicle controlled via Wi-Fi, equipped with an ESP32-CAM module, an ESP32 microcontroller, and advanced sensors to enhance situational awareness and ensure safety. Inspired by modern Advanced Driver Assistance Systems (ADAS), the vehicle is fitted with ultrasonic distance sensors to detect surrounding obstacles, a sound sensor for auditory feedback, and an automatic braking mechanism when an object is detected at a critical distance.

The system utilizes an ESP32 microcontroller with Wi-Fi connectivity and is controlled via a programmable Web, allowing users to operate the vehicle remotely with ease via a mobile device. The ESP32-CAM module provides a live video feed, enabling precise monitoring and real-time control. Ultrasonic sensors continuously scan the environment, working in conjunction with data processing algorithms to dynamically adjust the vehicle's movement . The sound sensor enhances user interaction by triggering an audio warning system when the vehicle nears an obstacle, ensuring an additional layer of safety.

I. Introduction

As technology continues to advance rapidly, the need for automation and remote control in many industries, including robotics and transportation, has increased significantly. Smart vehicles with real-time monitoring and automation are becoming an essential area of research and development.

Traditional remote-controlled vehicles often lack intelligent obstacle detection, real-time video streaming, and automatic safety mechanisms, which limits their effectiveness in practical applications such as surveillance, smart mobility, and autonomous navigation.

To address these challenges, IoT technology provides a connected ecosystem in which sensors, microcontrollers, and wireless communication modules work together to improve vehicle control, environmental awareness, and safety. A promising approach is to integrate the ESP32-CAM for live video streaming, the ESP32 microcontroller for wireless control, ultrasonic sensors for obstacle detection, and acoustic sensors for acoustic feedback, ensuring a more interactive and responsive system.

IoT enables data collection from various embedded devices, including cameras, ultrasonic distance sensors, and acoustic sensors. This data can be transmitted over Wi-Fi to a remote server or edge device, processed in real time, and used for decision making. The Web program provides an intuitive interface for users to remotely control the vehicle, monitor live camera feeds, and receive real-time alerts. Furthermore, the ultrasonic sensor continuously scans the surrounding environment, triggering the acoustic sensor to generate an audible alert to alert the user.

II. MAIN PROPOSAL

A. System models and block diagram

The developed system includes both hardware and software components.

On the hardware side, the system integrates two types of sensors to measure the distance of the vehicle from objects in the front and rear, a robot chassis, an AI Camera Module (ESP32-CAM), a DC motor with a motor driver (L298N or TB6612FNG), a Piezo buzzer, and an encoder.

ESP32 and ESP32-CAM are utilized as the IoT platform, where the ESP32, with its built-in Wi-Fi module, transmits data to the IoT server (Web program).

On the software side, a computer program is developed to execute the desired functionalities. A block diagram, as shown in the figure above, provides a clear visual representation of the entire system.

From the diagram, a distinct understanding of all integrated modules/devices and their responsibilities at a macro level can be obtained.

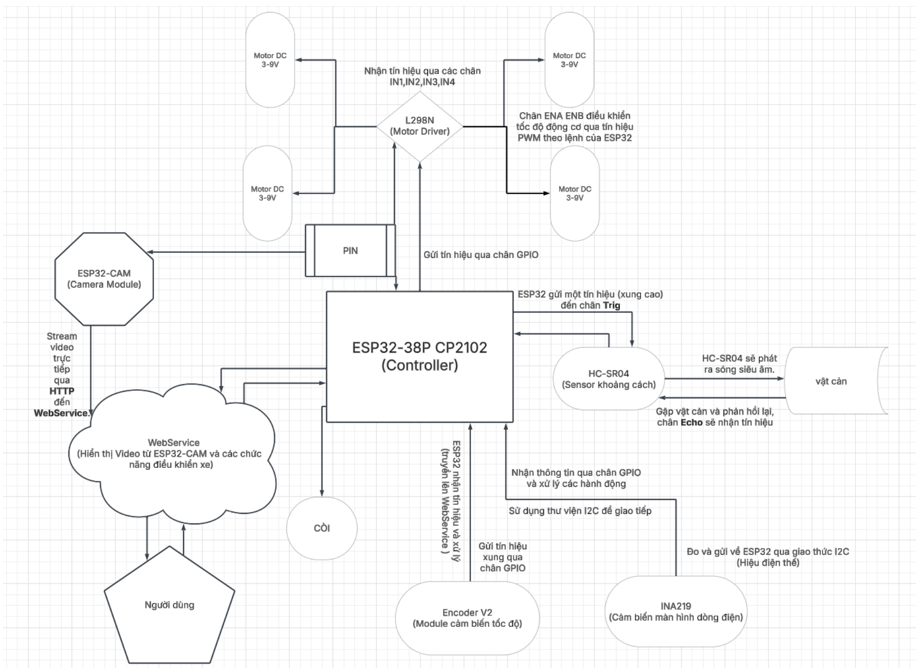


Fig. 1. Block diagram of the camera remote control car.

For the input side of the ESP32:

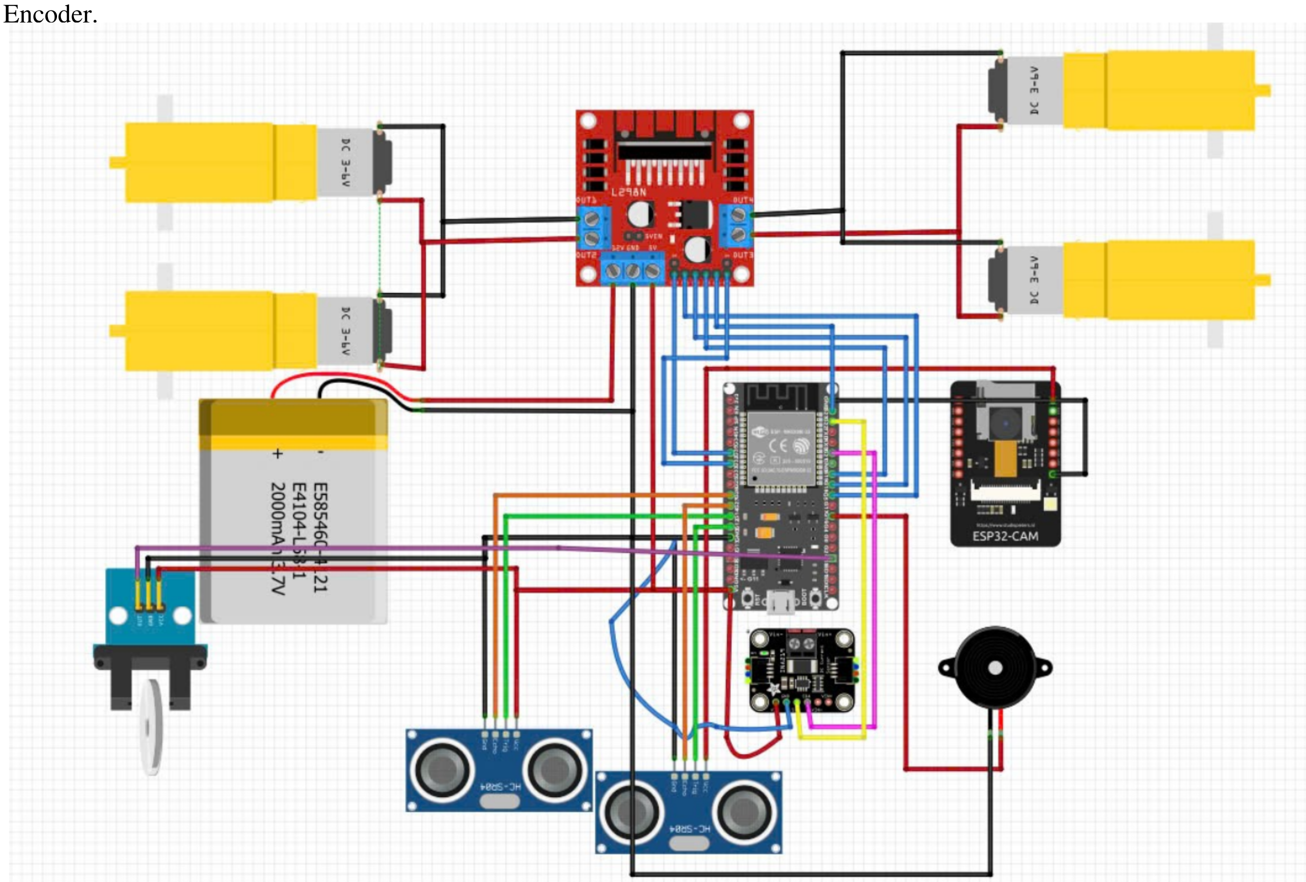
It connects to a speaker and two distance sensors (front and rear) to facilitate object detection. The ESP32-CAM AI Camera Module processes images. The DC motor and motor driver L298N control movement. The Battery charging circuit supplies power. The system also includes a Piezo buzzer and an Encoder. The built-in Wi-Fi module of the ESP32 is used to connect the system to the IoT server (Web program).

B. Components and peripheral devices

The following is a list of components for a mobile robot chassis:

1. Robot Chassis - Can use an acrylic frame with 2 wheels or 4 wheels.
2. Main Microcontroller.
3. AI Camera Module (ESP32-CAM or OpenMV Cam H7) - Used for image processing.
4. DC Motor + Motor Driver (L298N or TB6612FNG) - Controls movement.
5. Distance Sensor (HC-SR04 or LiDAR TF Mini) - Used for obstacle avoidance.
6. Bluetooth Module HC-05 or ESP8266/ESP32 - Wireless connection.
7. Li-ion 18650 Rechargeable Battery + Battery Charging Circuit - Provides power.
8. Wheels + Caster Wheel.

9. fPiezo.
10. Encoder.



Hardware connection of remote control car with camera.

C. *Software programming*

1. Arduino IDE - Write control code..
2. OpenMV IDE or ESP32-CAM firmware - Program image processing..
3. Frontend - Web HTML/CSS/JS.
4. WebSocket - Bridge between Frontend and Backend..

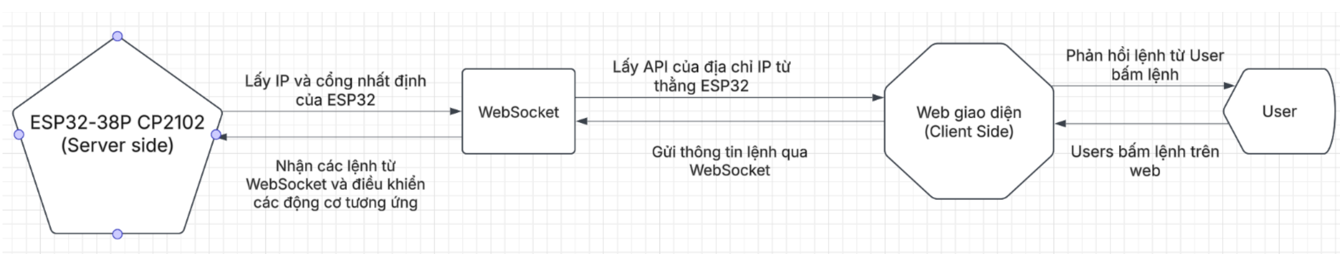


Fig. 2. Web Controller Diagram.

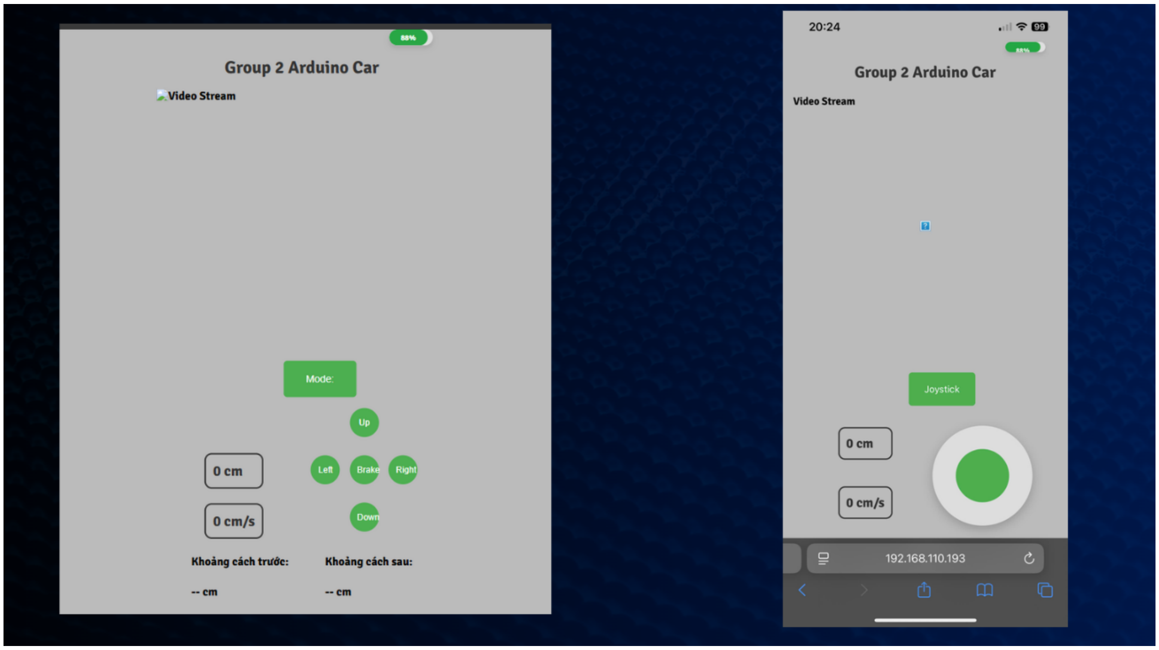


Fig. 3. Web Control Car on Laptop and SmartPhone.

D. Schematic and Programming Flowchart

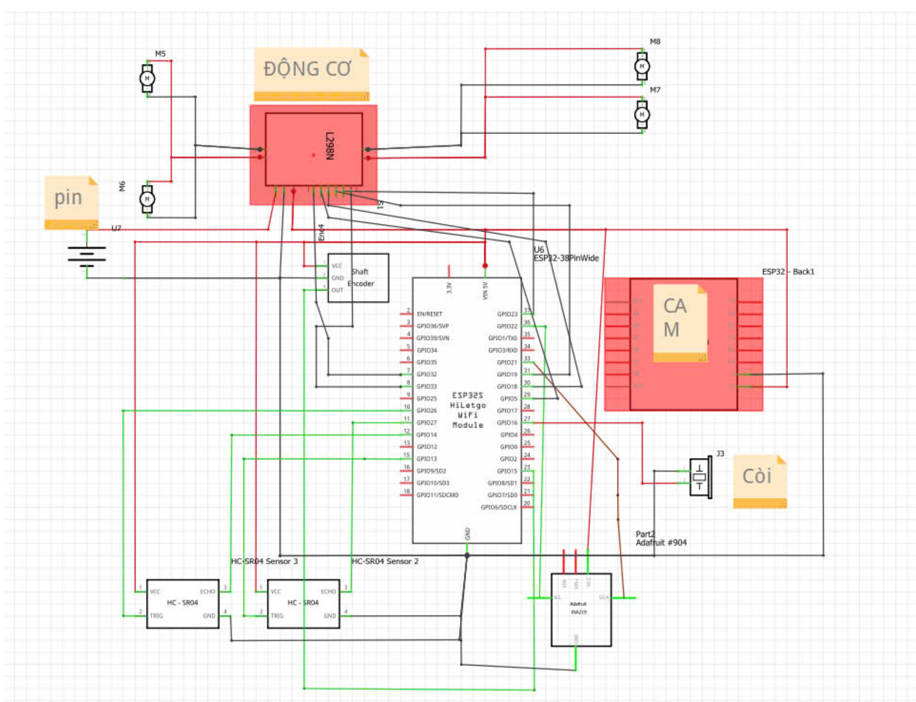


Fig. 4. Schematic of remote control car with camera.

Fig. 5. Flow chart of remote control car with camera.

The ESP32 is a powerful microcontroller-based device with built-in Wi-Fi and Bluetooth capabilities. Unlike the Arduino Uno, which uses the ATmega328P microcontroller, or the NodeMCU, which is based on the ESP8266 Wi-Fi chip, the ESP32 offers greater processing power and more GPIO pins for interfacing with various components.

In the presented work, the ESP32 is programmed to control a motor driver (L298N) for movement, measure distances using HC-SR04 ultrasonic sensors, monitor voltage and current via the INA219 module, and track motor speed with an encoder. The system also integrates a speaker for audio output and connects to an ESP32-CAM for streaming video to a WebServer at the IP address 192.168.1.100. The Arduino IDE software is used to program the ESP32, following the general attributes of ESP32 programming.

The programming logic for the system is described using a flowchart (Fig.2). According to the flowchart, the ESP32 processes data from the HC-SR04 sensors to detect obstacles, adjusts motor control via the L298N driver, and monitors power consumption through the INA219 module, while continuously streaming video through the ESP32-CAM to the designated WebServer for remote monitoring.

Table: Interfacing between ESP32 and its components (pin-to-pin)

ESP32	L298N (Motor Driver)	HC-SR04 (Distance Sensor)	INA219	Encoder	Speaker	ESP32-CAM
GND	GND	GND	GND	GND	GND	GND
VCC (3.3V/5V)	VCC	VCC	VCC	VCC	VCC	VCC
GPIO 5	IN1 (Left motor up)					
GPIO 18	IN2 (Left motor down)					
GPIO 19	IN3 (Right motor up)					
GPIO 23	IN4 (Right motor down)					
GPIO 32	ENA (PWM Motor 1)					
GPIO 33	ENB (PWM Motor 2)					
GPIO 26		TRIG1 (Front sensor)				
GPIO 14		ECHO1 (Front sensor)				
GPIO 13		TRIG2 (Rear sensor)				
GPIO 27		ECHO2 (Rear sensor)				
GPIO 15				ENCODER_PIN		
GPIO 21			SDA			
GPIO 22			SCL			
GPIO 16					Speaker	

Fig. 6. Detail connect of the camera remote control car.

III. Results and Discussion

A. Prototype Implementation

The developed smart vehicle system presented in this paper is practically implemented based on the block diagram and circuit design discussed above, using the components and peripheral devices listed. The written programming code, following the designed flowchart, is deployed on the ESP32 microcontroller to achieve full functionality. The prototype integrates motor control via the L298N driver, ultrasonic sensors (HC-SR04) for obstacle detection, an encoder for speed measurement, and an INA219 module for power monitoring. Live video streaming is enabled through the ESP32-CAM, operating via a web server. The entire system is powered by a stable DC supply, with a fixed IP (192.168.1.100) ensuring reliable remote communication. The implementation follows a modular approach, allowing seamless integration and efficient real-time control.

B. Experimental Results

The integration of the ESP32-CAM successfully provided real-time video streaming, allowing users to remotely observe the environment (Fig.7). Although occasional latency was observed during video transmission due to network conditions, the overall image quality remained sufficient for basic surveillance and navigation (Fig.8).

The encoder performed efficiently during testing(Fig.5). While it did not require as much processing as other sensors, it effectively measured the vehicle's speed and distance traveled.

The ultrasonic sensors detected obstacles well within the predefined range (Fig.4). However, in some cases, sensor accuracy was affected by object surfaces and environmental conditions, requiring minor adjustments to improve reliability.

Additionally, the sound sensor functioned as expected, generating audible warnings upon detecting obstacles (Fig.4). This feature enhanced user awareness and safety during operation.

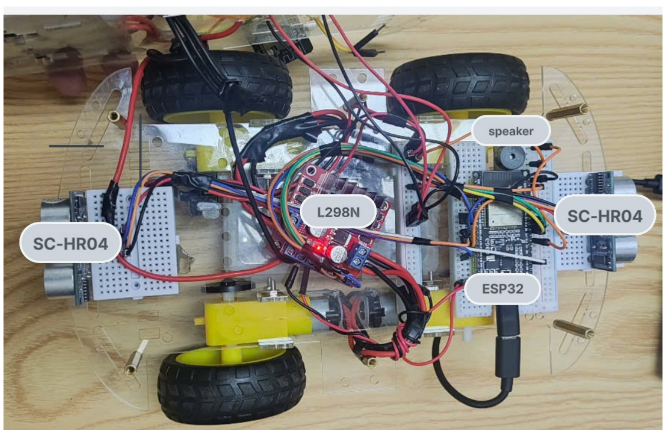


Fig. 7. (Inside view).

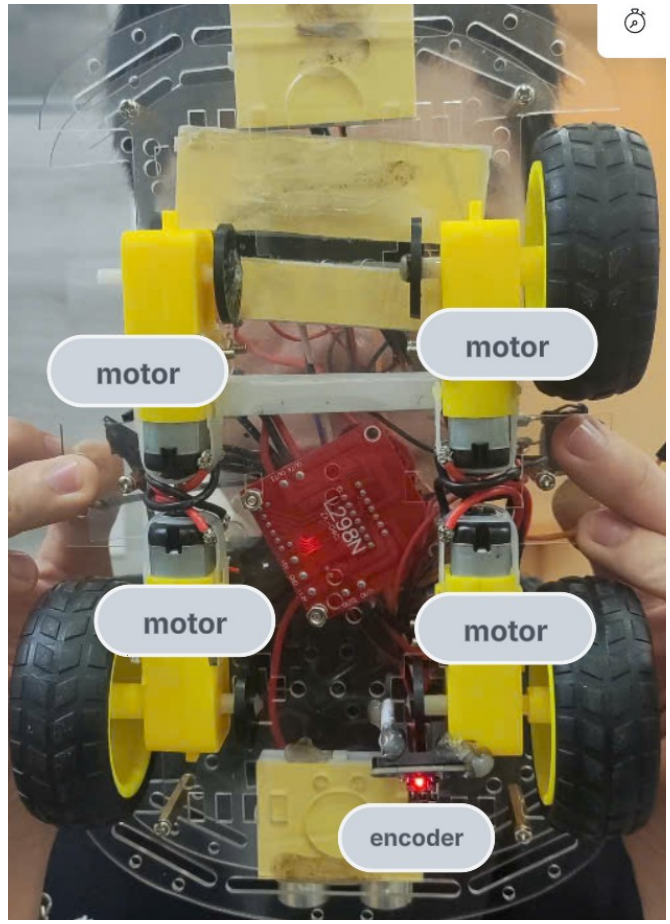


Fig. 8. (Bottom view).

One of the more challenging components was the INA219 sensor(Fig.6). It occasionally failed to measure battery life accurately and sometimes malfunctioned, significantly extending the testing duration.

A custom-developed Web provided a user-friendly interface for remote operation (Fig.6), displaying live video feeds and real-time sensor data, such as battery status, vehicle speed, and distance traveled. The wireless control system functioned efficiently within the Wi-Fi range. However, performance issues were noted in areas with weak connectivity, leading to connection failures that caused inconvenience and frustration.

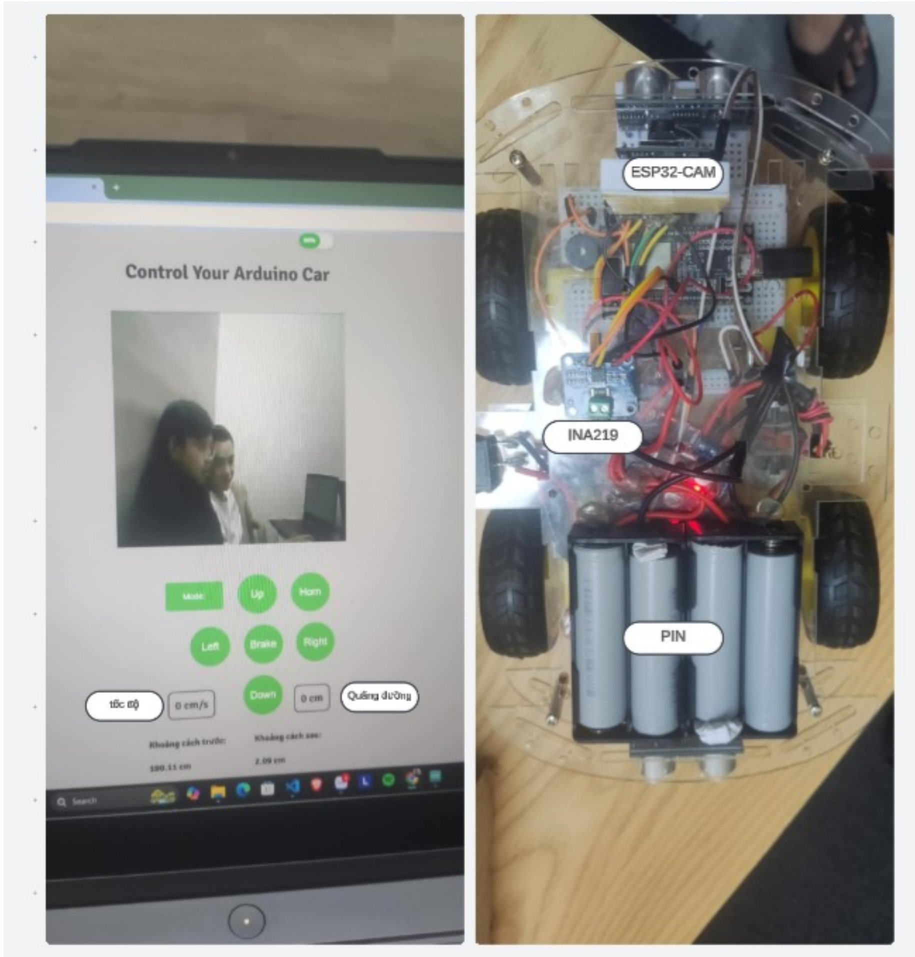


Fig. 9. Web And Top of remote car with camera

C. Discussion

For remote-controlled vehicles equipped with cameras, the ability to monitor and collect real-time data is a significant advantage. With live video streaming, users can observe situations remotely without needing to be physically present at the scene (Fig.6). This is particularly useful in applications such as security surveillance, rescue operations, and traffic management.

Additionally, the integration of ultrasonic sensors enables the vehicle to detect and avoid obstacles, enhancing movement accuracy. Compared to fixed surveillance systems, smart vehicles offer greater flexibility, allowing them to access various locations and operate even in hazardous environments.

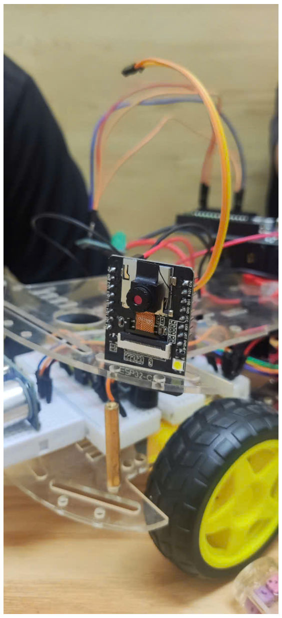


Fig. 10. ESP32-CAM with remote control car.

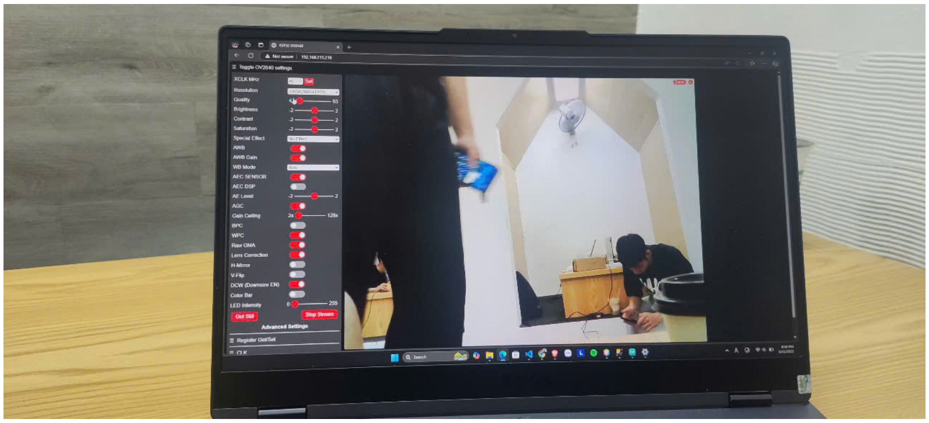


Fig. 11. Camera running

However, despite this flexibility, there are limitations in signal transmission and reception. Firstly, the video quality of the ESP32-CAM can be affected by network latency and signal interference, especially in environments with many obstacles. If the image data is unclear or disrupted, the effectiveness of surveillance can be significantly reduced.

Furthermore, smart vehicles rely on Wi-Fi for operation, which can pose a problem if the deployment area lacks a stable network connection. A viable solution is to use mobile networks (4G/5G) to ensure continuous connectivity, but this would increase operational costs.

IV. Completed Product

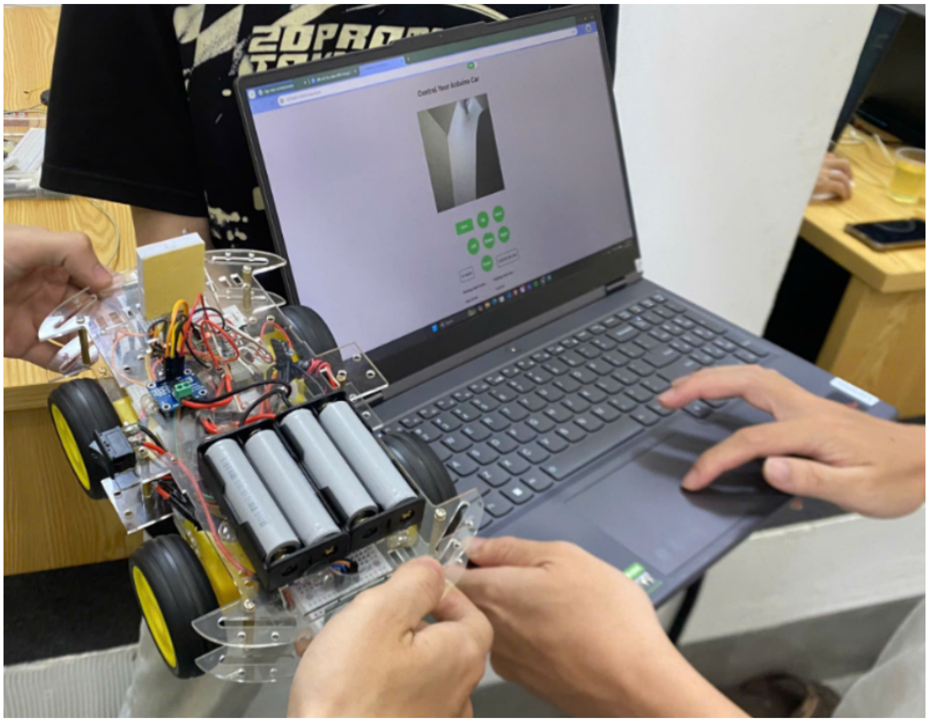


Fig. 12. Complete product and web control

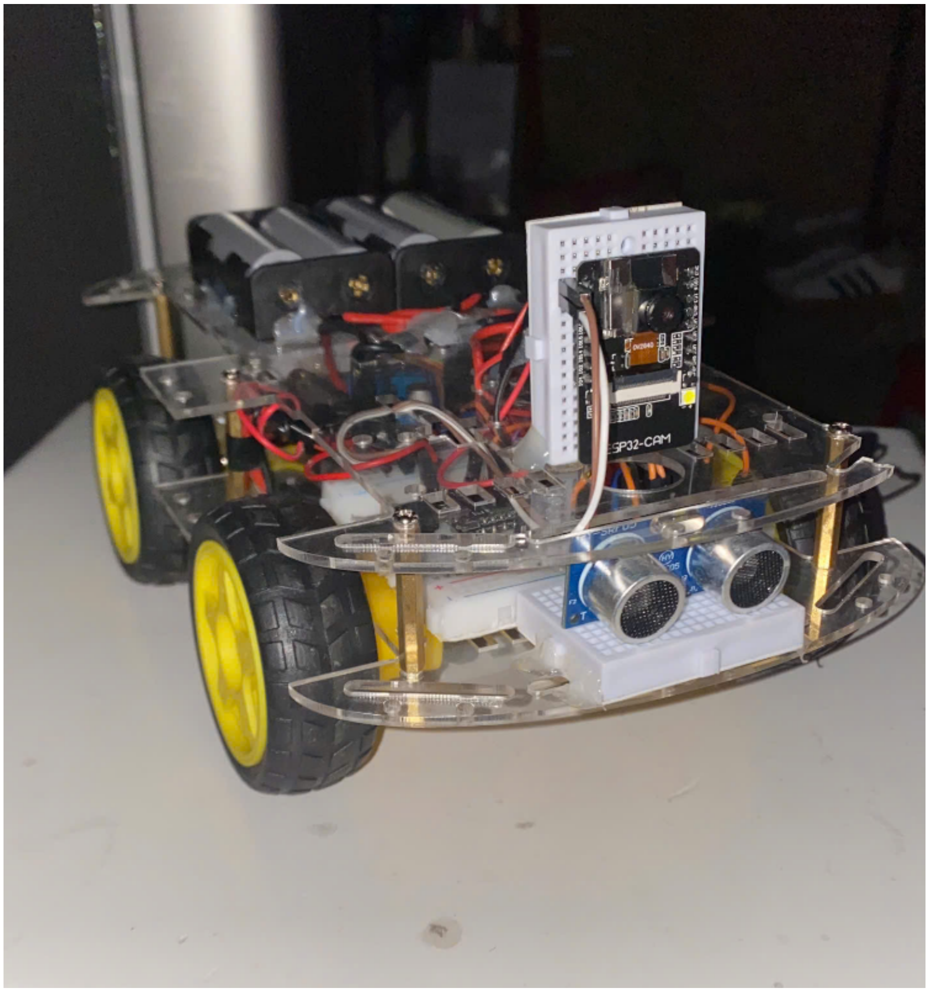


Fig. 13. Complete remote control car with camera.

V. Conclusion

The camera-equipped remote-controlled car project successfully demonstrates a practical solution to real-life challenges by integrating advanced sensing and monitoring technologies. The vehicle effectively detects obstacles within a specified range using the HC-SR04 distance sensor, enabling it to slow down and provide alerts, thus enhancing safety during operation. The ESP32-CAM module allows for real-time observation and recording of the surroundings, offering valuable data that can be used for safe driving, as well as preventing adverse situations such as theft, accidents, or other context-specific incidents. Additionally, the encoder accurately calculates the car's speed, while the INA219 module monitors voltage and current, enabling the system to determine the vehicle's speed, battery duration, and overall power consumption. This project highlights the potential of combining the ESP32 with various sensors and modules to create a versatile and efficient system for both practical applications and experimental purposes, paving the way for further advancements in autonomous vehicle technology.

VI. AUTHOR'S CONTRIBUTION

TABLE I
AUTHOR'S CONTRIBUTION

#	Student ID	Student Name	Tasks	Contribution
1	DE180169	Nguyen Nhat Sinh	Support write report, Program Arduino, Support Code Web, Test Sensor	16%
2	DE180171	Le My Loc	Write report, Design UI, Support Code Web and Test Sensor	16%
3	DE180173	Nguyen Minh Hieu	Deputy, Physical Design of the Project, Support Code Backend and Presentation	17%
4	DE180210	Cao Minh Tuan	Team Leader, Prepare Slides, Physical Design of the project, Code Sensor, Finalize report, Presentation	17%
5	DE180522	Dinh Gia Huy	Deputy, Leader Code Program Arduino - Backend and Support Physical Design	17%
6	DE190244	Nguyen Chon Phuoc	Presentation and Leader Code Frontend - Web Controller	17%
Total				**100%**

REFERENCES

[1] N. E. Titus, "The role of advanced driver assistance systems (adas) in improving road safety," *Research Output Journal of Engineering and Scientific Research*, vol. N/A, no. N/A, pp. 30–32, 2024, accessed: 2025-03-22. [Online]. Available: https://rojournals.org/the-role-of-advanced-driver-assistance-systems-adas-in-improving-road-safety

[2] N. Instruments, "What is adas? advanced driver assistance systems," 2023, accessed: 2025-03-22. [Online]. Available: https://www.ni.com/en/solutions/transportation/adas-and-autonomous-driving-testing/what-is-adas.html

[3] P. M. Greenwood and associates, "Advanced driver assistance systems (adas): Demographics, preferred sources of information, and accuracy of adas knowledge," *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 86, pp. 131–150, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/abs/pii/S1369847821001820

[1]. [2]. [3].