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Wi-Fi Controlled Surveillance Car with Tilting Camera

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Abstract: The Wi-Fi Controlled Surveillance Car is a system built for monitoring and safety purposes using IoT technology. It uses Wi-Fi to create a wireless connection between the user and the car. The main function in the ESP32 microcontroller, which serves as the main controller of the project. Using the web page or mobile app, the car can be driven over a local network. It has live video capabilities from an tilting camera for real time monitoring of its surroundings. Motor drivers utilize the DC motors to achieve smooth motion and control of direction. The device has the ability to eliminate the drawbacks of traditional wired or Bluetooth based control methodology. The purpose of the added advantage allows the user to operate over much wider distance and with flexibility in their exercises and its operation. Designed to be lightweight, portable, and applicable both indoors and outdoors, this device is easily transportable. Additionally, it allows for other capabilities such as obstacle detection through the use of additional sensors, as well as environmental monitoring. The Wi-Fi Surveillance Car is built in a way to consume very little power while remaining affordable. Its uses can extend from defence, disaster factors, and home security, as it serves as IoT robotics monitoring prototype overall. In conclusion, it shows a cost effective, useful, scalable and efficient, intelligent approach onto what modern surveillance could include now.

Keywords: Wi-Fi, IOT, monitoring, surveillance, control

I. INTRODUCTION

The Wi-Fi Controlled Surveillance Car is a modern, versatile technology that combines wireless communication, embedded systems, and robotics. It creates a mobile platform for remote observation and control. In today's world, security and surveillance are crucial for daily life. This project aims to meet the growing need for efficient, flexible, and remotely operated monitoring systems. Users can control a small car equipped with a live streaming camera through a Wi-Fi connection. The car operates using a smartphone, tablet, or computer on the same network, offering a user friendly and portable solution for real time surveillance.

The system uses a microcontroller that processes commands received over Wi-Fi to control the motors' movement. A motor driver circuit powers the wheels, enabling smooth movement in forward, backward, left, and right directions. A Wi-Fi module like the ESP32 enables wireless communication between the user and the car. The tilting camera streams live video directly to the user's device. A simple web interface or mobile app allows users to monitor the video feed, control the robot's movement, and manage system settings remotely. This feature is especially useful in situations where human presence is dangerous, such as hazardous environments, military zones, or disaster areas.

The Internet of Things (IOT) has revolutionized robotics by enabling real time data collection, remote monitoring, and automated decision making [6]. The Wi-Fi controlled surveillance car showcases a practical use of the Internet of Things concept by connecting physical hardware to the internet for remote access and control. It shows how embedded systems and wireless networks can work together to create intelligent devices that can operate autonomously or semi autonomously. Additionally, the project can be improved by adding features like motion detection, infrared cameras for night vision, GPS tracking, and obstacle avoidance sensors to enhance its reliability.

This project has many potential uses, including home and office security, border patrol, search and rescue, and industrial inspection. It offers an efficient way to monitor challenging or risky areas, reducing danger and improving safety. From an educational standpoint, the Wi-Fi controlled surveillance car is an excellent learning tool for students and hobbyists interested in electronics, wireless communication, and robotics. It encourages creativity and innovation while helping learners grasp real world applications of modern technologies.

In summary, the Wi-Fi Controlled Surveillance Car represents a significant advancement in intelligent surveillance systems. It demonstrates how automation and connectivity can transform security and monitoring processes. By combining mobility, live video transmission, and wireless control, it provides a cost effective and efficient solution for various surveillance needs, paving the way for safer environments.

II. Literature Survey

A wide range of studies explore the design and implementation of robotic cars and surveillance systems using modern microcontrollers such as the ESP32, Arduino, Raspberry Pi, and ESP8266. Several works focus on Wi-Fi and Bluetooth-controlled robots that provide remote operation through mobile apps, web interfaces, or smartphone-based controls. These systems commonly use motor drivers like L298N or L293D, along with modules such as HC-05/HC-06 Bluetooth, ESP8266 Wi-Fi, and ESP32-CAM for real-time video streaming. Many designs also incorporate IP cameras, Android apps, or web dashboards to enable long-range monitoring, surveillance, and navigation across rough or hazardous environments. Some projects extend the functionality with additional sensors such as GPS modules, flame sensors, PIR sensors, and temperature sensors, resulting in multipurpose robotic platforms capable of tracking, autonomous monitoring, and environment sensing.

Another set of studies focuses on autonomous navigation and intelligent control techniques. Robots using ESP32-CAM and Raspberry Pi Pico process visual data through image processing algorithms to detect lines, obstacles, or motion. Instead of relying on basic IR sensors, these systems adopt advanced methods such as fuzzy logic controllers for line detection, ultrasonic sensors mounted on servo motors for scanning surroundings, and hybrid IoT plus-manual control systems to maintain reliability even under unstable network conditions. Some research also emphasizes dual-operation modes manual (via Bluetooth or Wi-Fi) and autonomous allowing smooth switching between user control and automatic pathfinding. Gesture-controlled systems using MPU6050 modules and NRF24L01 radios show further innovation, enabling robots to respond to hand movements for intuitive navigation.

Several advanced works extend beyond robotics into power electronics and intelligent control. One study compares PI and PID controllers with modern AI-based methods such as Fuzzy Logic, Artificial Neural Networks, and ANFIS for optimizing DC to DC buck converters used in lithium-ion battery charging. The performance evaluation includes MATLAB or Simulink simulations and Hardware-in-the-Loop testing using OPAL-RT, addressing challenges like nonlinearity and dynamic variations. Another project applies IoT and AI to smart city mobility, using ESP32-CAM to collect visual data such as traffic density and parking occupancy, which is then analysed using YOLOv3 algorithms to support low cost intelligent transportation planning.

Finally, some studies focus on long-range connectivity and enhanced surveillance capabilities through 4G/LTE networks and cloud platforms. Raspberry Pi-based systems programmed with Node.js use 4G modules and gimbal-stabilized cameras to stream high-quality video and enable remote control from virtually anywhere. Voice-controlled surveillance robots integrate platforms like Google Assistant, IFTTT, and Adafruit.io to transform voice commands into movement and monitoring actions, while maintaining additional safety through ultrasonic obstacle detection and fire-alert sensors. Collectively, these studies highlight the rapid evolution of robotics, IoT, and intelligent control systems, demonstrating how modern microcontrollers, wireless communication, and AI algorithms can produce versatile, low-cost, and highly efficient robotic vehicles for surveillance, navigation, and smart automation applications.

III. Methodology

We use ESP32 CAM, which acts as both the brain and eye of the system. The ESP32 CAM is responsible for image capturing, video streaming, and handling WI-FI communication. It is connected to a motor driver module (L298N), which controls the DC motors that drive the wheels of the car. The L298N motor driver allows forward, backward, left, and right movements by adjusting the direction and speed of the motors.

The car chassis is assembled using a 4WD setup, where the motors and wheels are mounted securely. The ESP32 CAM, motor driver, power supply and buck converter are fixed onto the chassis. Proper wiring is done to interconnect all components, ensuring stable power and signal flow.

We use the Arduino IDE to program the ESP32 CAM using a USB to serial converter since the ESP32 CAM lacks a built in USB interface. The code uploaded to the ESP32 CAM configures it to create a local web server, enabling real time video streaming and motor control via WI-FI.

When powered on, the car automatically creates its own WI-FI network. The user connects their smartphone, tablet, or laptop to this network and opens the web server's IP address in a browser. The web interface displays the live video feed from the camera and includes control buttons for navigation.

To enhance functionality, a servo motor is added for tilting movement of the camera, providing a wider field of view. This allows users to look around without physically moving the car. The servo motor is also controlled via the same web interface.

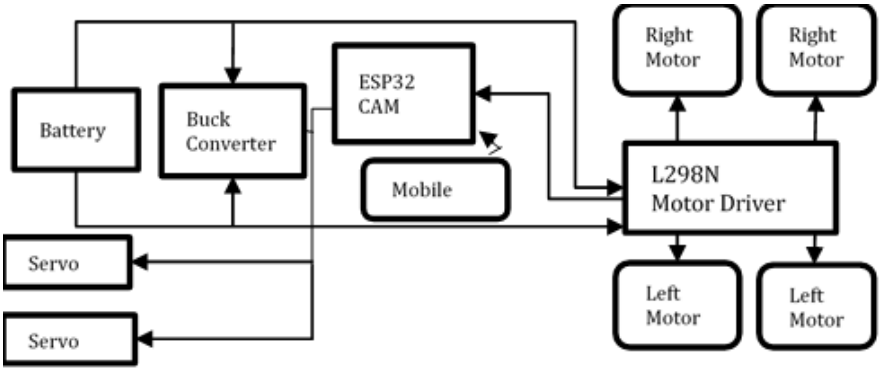

Fig 1: Block Diagram of Wireless Video Surveillance Car

Explanation

This project is a WI-FI Controlled Surveillance Car centred on the ESP32 CAM, which serves as the robot's brain and streams live video. The car's movement comes from DC motors driven by an L298N motor driver. To ensure stable camera coverage, two servo motors create a tilting system, allowing the user to remotely swivel the camera's view. All components are powered by a battery whose voltage is safely regulated by a buck converter. The user controls both the car's direction and the camera's angle remotely through a simple web interface accessible on any smartphone or computer connected to the car's WI-FI network.

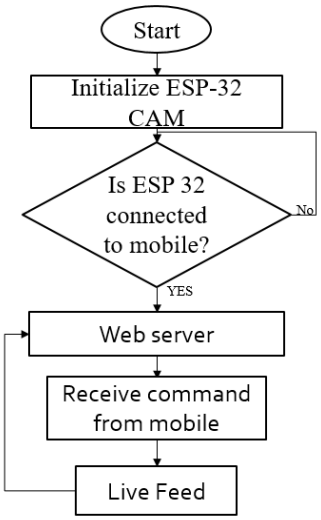

Fig 2: Flowchart of Wireless Video Surveillance

IV. Working

The WI-FI controlled surveillance car works by using ESP32 CAM as the main controller and camera module. When it is powered on, the battery supplies power to all components through a buck converter, which provides a stable voltage. The ESP32 CAM creates its own WI-FI network, which can be connected to using a smartphone. Once connected, the user can open the IP address of the ESP32 CAM in a web browser to access the live video feed and control panel.

Through this web interface, the user can send commands to move the car forward, backward, left, or right**.** These commands are received by the ESP32 CAM and passed to the L298N motor driver, which controls the four DC motors accordingly. At the same time, the servo motors connected to the ESP32 CAM control the tilting movement of the camera, allowing the user to adjust the camera angle remotely.

As the car moves, the live video from the ESP32 CAM is streamed directly to the mobile device, enabling real time surveillance. This setup allows the user to monitor areas wirelessly and control both the car’s movement and camera direction efficiently.

V. Result

We successfully designed and implemented WI-FI controlled surveillance car using the ESP32 CAM module. It create its own WI-FI network, allowing the user to connect via a smartphone and access the live video stream through a web browser. The movement of the car was efficiently controlled through the web interface, enabling smooth forward, backward, left, and right motion. The tilting camera mechanism worked effectively, allowing real time adjustment of the camera angle for wider area coverage. The overall system operated reliably, providing clear video transmission and responsive controls.

The Figure as shown below represents the complete assembly of the Wi-Fi Controlled Surveillance Car. It includes the ESP32-CAM module for live video streaming, L298N motor driver for motor control, and rechargeable batteries for power supply.

Fig 3: Fully Integrated Wi-Fi Surveillance Car Setup with Power Supply, Motor Driver, and Camera Module

The Figure as shown below the camera tilting mechanism of the surveillance car. The ESP32-CAM is mounted on a servo-based tilting setup that allows vertical and horizontal movement

Fig 4: Camera Tilting Mechanism Demonstration

The Figure as shown below describes the camera module actively capturing its surroundings in real time.

Fig 5: Camera Module Actively Capturing Surroundings for Surveillance

The Figure as shown below displays the web interface used to control the ESP32-CAM surveillance car. It provides directional buttons, speed, and camera control sliders for real-time operation.

Fig 6: Live Video Feed and Directional Control Interface for ESP32-CAM Surveillance Car

VI. Conclusion

The Wi-Fi Controlled Surveillance Car represents a significant advancement in modern surveillance and automation technologies, combining robotics, wireless communication, and embedded systems to create a highly versatile and practical monitoring solution. Through its Wi-Fi connectivity, users can remotely control the car and access a live video feed from its onboard camera, allowing real time observation of areas that may be hazardous, difficult to access, or require constant monitoring. This remote operation not only enhances safety but also increases efficiency by reducing the need for human presence in risky environments.

Equipped with a microcontroller, motor driver, and camera module, the surveillance car demonstrates a seamless integration of hardware and software, highlighting the potential of the Internet of Things (IoT) in everyday applications. The system can be further enhanced with sensors for obstacle detection, night vision cameras, and GPS modules, making it capable of operating autonomously or in complex environments. Its applications are wide ranging, from home and office security to industrial inspection, disaster management, and military reconnaissance, proving its adaptability to diverse scenarios.

Beyond its practical uses, the project serves as an educational tool for students and hobbyists, providing hands on experience with robotics, embedded systems, and wireless communication. It encourages problem solving, innovation, and technical creativity, bridging theoretical knowledge with real world implementation. The Wi-Fi Controlled Surveillance Car exemplifies how modern technology can be harnessed to create smart, safe, and efficient monitoring solutions.

In summary, this project underscores the importance of integrating mobility, remote access, and real time monitoring to develop intelligent surveillance systems. It offers a cost effective, flexible, and reliable approach to enhancing security and safety, demonstrating the transformative potential of wireless controlled robotic systems in a rapidly evolving technological landscape. By combining functionality, accessibility, and adaptability, the Wi-Fi Controlled Surveillance Car is a forward looking solution that addresses contemporary surveillance challenges while opening avenues for future innovations.

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