

Robo Scout Explorer: Autonomous Wireless Surveillance System

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Abstract: This paper introduces the design and implementation of the Robo Scout Explorer, an autonomous wireless surveillance system developed with an ESP32 camera module and various IoT components. Tailored for security and monitoring purposes, the system features real-time video streaming, remote control capabilities, and autonomous navigation for accessing difficult-to-reach areas. Key enhancements to the base design include the integration of a buzz controller for efficient voltage regulation, the use of five 3.7V batteries to optimize power performance, and toggle switches for user-friendly power management. Furthermore, the camera module has been repositioned to enhance visibility, while cooling fans have been added to prevent overheating. These upgrades significantly extend the system's operational lifespan and adaptability, making it highly effective for diverse surveillance applications.

Keywords: ESP32 camera, BUZZ controller, L298N Motor Driver, L298N Motor Driver, Toggle Switches, SG90 Servo Motors.

I. INTRODUCTION

Autonomous surveillance systems have become essential in today's security infrastructure, offering the ability to monitor and record activities in remote and hazardous locations. Robo Scout Explorer is an innovative wireless surveillance car designed to meet the growing demand for versatile and cost-effective security systems. Unlike traditional systems, this project offers enhanced mobility, real-time video streaming, and user-controlled operations.

The base system uses the ESP32 camera module for capturing live video, which is transmitted to a mobile device over a Wi-Fi network. However, modifications were made to improve efficiency, power management, and system control, as well as to address issues such as overheating and limited operational range. This paper discusses the design, implementation, and improvements made to the initial model, along with its potential applications

in surveillance, search and rescue, and industrial inspection.

II. LITERATURE SURVEY

In [1], G. Anandravisekar, A. Anto Clinton, T. Mukesh Raj, L. Naveen, M. Mahendran has proposed a robot which execute the act of continuous supervision in the household areas. It is capable to reduce the human labour as well as human error. The robot is controlled by mobile or laptop through IoT with help of Cayenne software. It is used to send instruction to the robotic system. Arduino interfaced with ESP-8266 Wi-Fi module for unlimited range of operation receives those commands. DC motors, ultrasonic sensor to detect any obstruction, IR sensors and wireless camera that provides audio and video streaming data to the user end are used in this project.

In [2], Jignesh Patolia, Haard Mehta, Hitesh Patel, Patel.V.T discusses a system for observing the human movement in the war region and war border area which can minimize the risk of human life as soldiers of armed forces can assess the situation of the area prior enter into it. The warfield robot comprises Arduino Uno board was interfaced with L293D, HC-05 and night vision wireless camera. Camera is placed on the top of the robot and can monitor minimum of 100 m transmission distance. It has the feature of rotating 360 degrees by the means of android application. That android application is created through MIT app inventor and is used for the total navigation control of the robot.

In [3], Mohammad Shoeb Shah, P.B. Barole presents a cost effective robot using Arduino uno microcontroller which can carry out the act of surveillance as well as rescue operation. The robot is equipped with passive infrared sensor, ultrasonic ranging module, DHT11 temperature and humidity sensor, MQ-135 air quality sensor, accelerometer sensor, gyroscope sensor, magnetometer sensor,

GPS sensor, Bluetooth and WIFI module, motor driver and robotic arm. The robotic arm is a type of jointed arm and consists of gripper to pick up objects with ease. It is controlled remotely by end user via internet. Solar panel is also connected to provide with the facility to charge battery with solar power.

In [4], Diksha Singh, Pooja Zaware, Dr Anil Nadgaonkar has developed a surveillance robot for real time video streaming and audio transfer. The wireless mini robot is controlled by android based application named BLYNK. Arduino uno R3 is used as robot control board and it is incorporated with NodeMcu ESP module and L293D. ESP8266 Wi-Fi module is paired with android supported mobile device along with security credentials. Username and password is only known by the authorized person also by predefined by the developer in the programming of the system.. It makes this wireless mini robot control completely secured from trespasser.

III. HARDWARE DESIGN

The hardware design of the Robo Scout Explorer incorporates several components, each of which plays a critical role in the overall performance of the system. The following sections describe the main hardware elements and the changes made to enhance the system's functionality.

A. ESP32 Camera Module

The ESP32-CAM is the core component of the system, providing real-time video streaming capabilities over Wi-Fi. This small, low-power module supports a range of IoT applications, including wireless monitoring, image capture, and data transmission. In the modified design, the camera module was reoriented vertically to improve visibility and capture a wider field of view. This change allows for more effective monitoring, particularly in confined spaces or narrow corridors.



Fig - 1 ESP32-CAM

B. Buzz Controller for Voltage Regulation

To protect sensitive components like the ESP32 camera and Wi-Fi module from voltage fluctuations, a buzz controller was added. This controller regulates the voltage supplied to the system, preventing overloads that could damage the hardware. Voltage regulation is critical in environments where power supply stability is not guaranteed, ensuring that the system remains operational for extended periods [6+source] .

C. Power Supply Configuration

One of the major modifications to the original design was the replacement of two 9V batteries with five 3.7V lithium-ion batteries. This change significantly improves the system's power efficiency, providing a more stable and longer-lasting power source. Lithium-ion batteries are known for their high energy density and longer charge cycles, making them ideal for continuous surveillance operations.



Fig - 2 Power Supply

D. Toggle Switches for Power Management

To enhance user control and conserve energy, toggle switches were introduced. These switches allow users to manually control the power to both the Wi-Fi module and the ESP32 microcontroller. By switching these components off when they are not in use, the system conserves battery power and extends operational time. This feature is particularly useful in long-duration surveillance scenarios, where power efficiency is crucial.

E. Cooling System for Temperature Regulation

Overheating is a common issue in systems that operate continuously for extended periods. To address this, cooling fans were integrated to regulate the temperature of both the ESP32 camera module and the motor driver. This ensures that the system remains functional even during long

surveillance sessions, preventing damage due to excessive heat.

F. L298N Motor Driver

The L298N motor driver module is used to control the DC gear motors that drive the movement of the vehicle. This motor driver can handle two DC motors with both speed and directional control, making it suitable for the precise movement required in a surveillance vehicle. The L298N can support a maximum voltage of 46V and current up to 2A per motor, enabling efficient power management while ensuring that the car can move smoothly and steadily during surveillance operation.

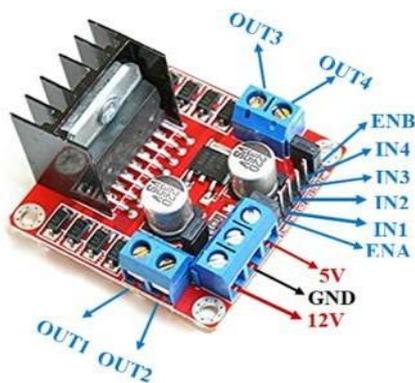


Fig – 3 L298N motor driver

G. DC Gear Shift Motors

The DC gear shift motors are responsible for propelling the car and providing movement across various surfaces. These motors have dual shafts, which allow for simultaneous control of both wheels and encoders for precise movement. Operating at voltages between 3V to 12V, these motors deliver a torque of 0.35 kg/cm and a rotational speed of 100 RPM, making them ideal for moderate terrain and navigation. Their lightweight design, ease of maintenance, and efficient shock absorption make them suitable for a mobile surveillance system that requires continuous operation without frequent downtime.



Fig - 4 DC Gear Shift Motors

H. SG90 Servo Motors

The SG90 servo motors are used to adjust the ESP32 camera module's tilt and pan. These servos are known for their precise control over angular movement, which is essential for adjusting the camera's view during surveillance. With an operational voltage range of 4.8V to 6V, the SG90 motors provide a 180-degree rotation, allowing the camera to cover a wide area. The precise positioning ensures that the camera module can focus on specific targets or areas of interest during monitoring.



Fig – 5 SG90 Servo Motors

IV. SYSTEM ARCHITECTURE AND BLOCK DIAGRAM

The system architecture of Robo Scout Explorer is designed to be both efficient and flexible.

The five 3.7V lithium batteries are connected in series, providing a stable power supply to the buzz controller, which regulates the voltage distributed to the ESP32 camera module, Wi-Fi module, and motor driver. The ESP32 camera module transmits live video to a mobile device, where users can control the vehicle's movement and adjust camera settings. The toggle switches allow users to manage power consumption by controlling when the Wi-Fi and ESP32 modules are active. The cooling fans ensure that the system operates within safe temperature limits. The buzz controller protects the system from voltage spikes, ensuring reliable operation in various environments.

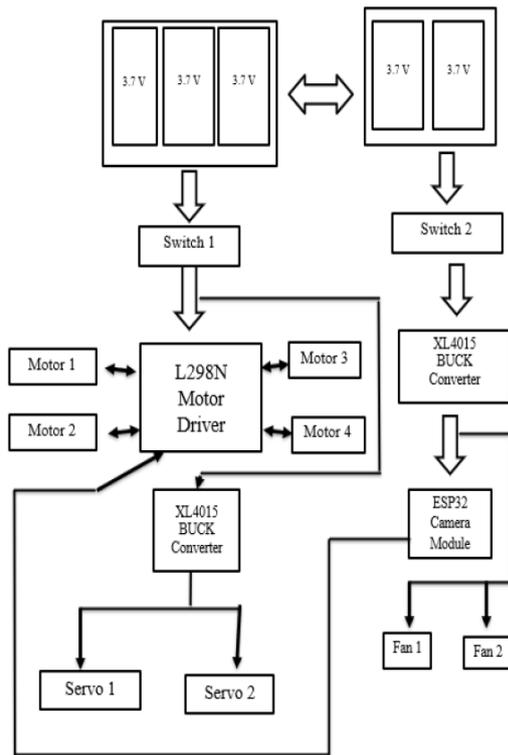


Fig – 6 Block Diagram

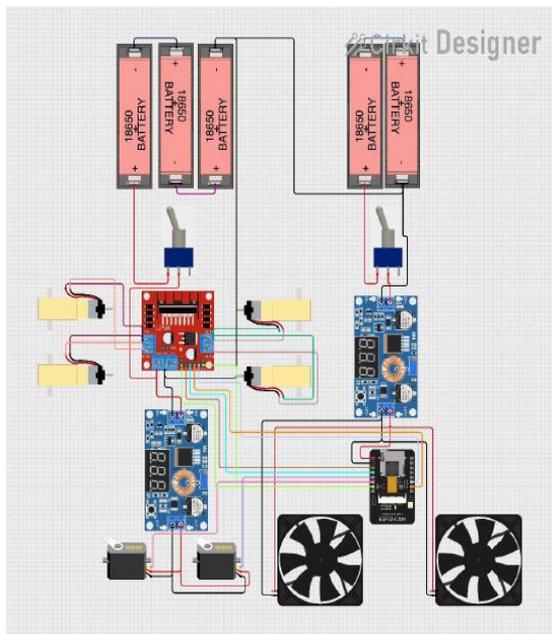


Fig – 7 Circuit Diagram

V. IMPLIMENTATON

The final design of Robo Scout Explorer incorporates several features that make it a versatile and reliable surveillance system. Below are the key design features:

- **Autonomous Navigation:** The system can navigate autonomously in predefined areas,

making it ideal for monitoring large spaces or dangerous environments.

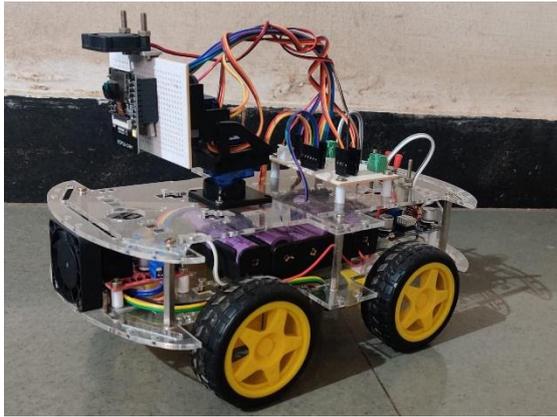
- **Real-Time Video Streaming:** The ESP32 camera module streams live video directly to a mobile device, allowing users to monitor areas in real-time.
- **Improved Power Efficiency:** The use of five 3.7V batteries increases the system's operational time, while the buzz controller ensures stable voltage levels across all components.
- **User-Controlled Power Management:** The toggle switches allow users to manage power consumption by controlling when the Wi-Fi and ESP32 modules are active.
- **Temperature Regulation:** The cooling fans help maintain a stable temperature during prolonged use, preventing overheating of the camera and other critical components.

VI. RESULT

The Robo Scout Explorer is controlled via a mobile device that connects to the system through the Wi-Fi module integrated into the device. Once the mobile device connects to the Wi-Fi network of the Robo Scout Explorer, the user can control the system remotely. The device streams real-time video from the ESP32 camera module to the mobile device, allowing the user to monitor the surroundings.

The user interacts with the system through a simple browser-based interface, where they can control the vehicle's movement, adjust the camera's tilt and pan, and manage other functionalities such as speed and lighting. The L298N motor driver controls the movement of the vehicle based on user input, while the SG90 servo motors adjust the camera's view. The power to the Wi-Fi module and ESP32 microcontroller can be controlled using toggle switches, allowing the user to conserve energy by turning off these modules when not needed.

In addition, the buzz controller regulates the voltage supplied to critical components, preventing overloads, while the cooling fans ensure that the system operates within safe temperature limits. This ensures smooth operation during surveillance tasks, even during prolonged usage.



VII. APPLICATIONS

The enhanced features of Robo Scout Explorer make it suitable for a wide range of applications:

- **Home Security:** The car can be used to monitor homes and properties, providing real-time video feeds and alerts to homeowners.
- **Search and Rescue Operations:** The system can navigate through debris or dangerous areas to search for trapped individuals, where human access is limited.
- **Industrial Inspection:** The car can inspect hard-to-reach areas in industrial facilities, providing visual feedback to operators and ensuring the safety of personnel.
- **Educational and Research Applications:** The system is an excellent tool for students and researchers interested in robotics, IoT, and real-time surveillance.

VIII. RESULT

The surveillance robot is designed with advanced capabilities to detect and transmit signals to authorized users from various environments. Using sensor data, the robot provides real-time information, allowing users to control its movement in the desired direction, such as left, right, forward, or backward. It can detect objects and identify approaching elements while offering live video streaming for effective monitoring. Each sensor is specialized for different functions, such as gas detection or live human detection. The robot can be easily operated remotely using an Android device or laptop, making it highly convenient and beneficial for areas that are inaccessible or pose life-threatening risks to humans.

IX. FUTURE WORK

The Robo Scout Explorer has already demonstrated significant advancements in surveillance technology, but there are several areas where further enhancements can be made. The following features are planned for future implementation:

1. **Robotic Arm Integration:** Plan to add a robotic arm to the top of the device. This arm will be capable of lifting and moving objects in its path, expanding the functionality of the vehicle.
2. **Cloud Storage Integration:** To enhance the data management capabilities, we aim to integrate cloud storage into the system. This will allow the device to store all recorded footage remotely, making it easy to access and review surveillance data whenever needed.
3. **Mobile App Development:** Plan to develop a dedicated mobile application that will simplify the user interface and allow for easy control of the device. The app will feature a streamlined control system, enabling users to operate the car and access all functionalities, including video recording and storage.
4. **Diagonal Movement Capability:** To increase the maneuver ability of the device, we will be adding diagonal movement features. This enhancement will allow the Robo Scout Explorer to move in any direction when required, offering greater flexibility and precision in navigating tight or constrained spaces.

With these upgrades, Robo Scout Explorer will be more versatile and comprehensive surveillance solution, suitable for a broader range of applications, from personal use to more complex commercial and industrial environments.

X. REFERENCES

- [1] JigneshPatolia, Haard Mehta, Hitesh Patel, Patel.V.T. "ArduinoControlled War Field Spy Robot using Nightvision Camera and Android Application". Department of Electronics and Communication of Engineering, Charotar University of Science and Technology, Changa, Anand, Gujarat - 388421, India". 5th Nirma University International Conference on Engineering (NUiCONE)",2015.
- [2] G. Anandravisekar, A. Anto Clinton, T.

- Mukesh Raj, L. Naveen, M. Mahendran, "IOT based Surveillance Robot". Department of Electronics and Communication Engineering Saranathan College of Engineering Trichy, Tamilnadu, India. "International Journal of Engineering Research & Technology (IJERT)", 2018.
- [3] Mohammad Shoeb Shah, P.B. Barole. "Surveillance and Rescue Robot using Android Smart Phone and Internet". International Conference on Communication And Signal Processing, India, 2016
- [4] Diksha Singh, Pooja Zaware, Dr Anil Nadgaonkar, "Department of Electronics & Telecommunication, DBATU, Lonere". 2nd IEEE International Conference On Recent Trends in Electronics Information & Communication Technology" (RTEICT), May 19-20, 2017.
- [5] K. Rajkumar and V. Dhanakoti, "Methodological Survey to Improve the Secure Data Storage in Cloud Computing," 2020 International Conference on Emerging Smart Computing and Informatics (ESCI), 2020.
- [6] S. S. Sengar, U. Hariharan, and K. Rajkumar, "Multimodal Biometric Authentication System using Deep Learning Method," 2020 International Conference on Emerging Smart Computing and Informatics (ESCI), 2020.
- [7] U. Hariharan, K. Rajkumar, Nilotpal Pathak, "Enhancing the Energy Efficiency using AMH Protocol for Wireless Sensor Networks", IJAST, vol. 29, no. 05, pp. 3607 - 3612, Apr. 2020.
- [8] Dr. V. Ramya and T. Akilan, "Embedded Controller for Intelligent Driver Assistant in Automatic System", International Journal of Applied Engineering Research, ISSN 0973-4562 Vol. 10 No.5, 2015, pp.531-537.
- [9] U. Hariharan and K. Rajkumar, "Prolong Network Lifetime Using Dynamic Routing for Wireless Sensor Networks," INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH, vol. 9, no. 3, pp. 7166-7169, Mar. 2020.
- [10] Nazirah Ahmad Zaini, Norliza Zaini, Mohd Fuad Abdul Latip, Nabilah Hamzah, "Remote Monitoring System based on a Wi-Fi Controlled Car Using Raspberry Pi", IEEE Conference on Systems, Process and Control (ICSPC 2016), 16-18 December 2016
- [11] V. Ramya, T. Akilan and N. Vignesh, "Designing an Embedded System for Autonomous Building Map Exploration Robot", International Journal of Computer Applications (0975-8887) Vol.73, No.10, July 2013, pp.11-17.
- [12] Kuppusamy, P., Rajkumar, K., Maheswar, R., Sheeba Rani, S., & Amiri, I. (2020). A long-reach radio over free space optics (Ro-FSO) system using hybrid orthogonal frequency division multiplexing (OFDM)-multibeam concept with enhanced detection, Journal of Optical Communications (published online ahead of print 2020), 000010151520190292. doi: <https://doi.org/10.1515/joc-2019-0292>
- [13] Ghanem Osman Elhaj Abdalla, T. Veeramanikandasamy "Implementation of Spy Robot for A Surveillance System using Internet Protocol of Raspberry Pi" 2017 2nd IEEE International Conference On Recent Trends In Electronics Information & Communication Technology, May 19-20, 2017
- [14] K. RajKumar, C. Saravana Kumar, C. Yuvashree, Mr. Senthil Murugan "Portable Surveillance Robot using IoT". Department of ECE, Valliammai Engineering College, Tamilnadu, India. " International Research Journal of Engineering and Technology (IRJET)", March 2019.
- [15] S Bagul, Vikram C Udawant, Kalpana V Kapade and 4 Jayesh M Zope, "IOT Based Surveillance Robot", International Journal of Trend in Research and Development (IJTRD) Mar-Apr 2018. Authorized.