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International Journal on Advanced Electrical and Computer Engineering

ISSN: 2349-9338
Volume 14 Issue 01, 2025

IOT Based Surveillance Robot

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Peer Review Information

Submission: 18 Jan 2025
Revision: 19 Feb 2025
Acceptance: 22 March 2025

Keywords

IoT-based Surveillance
ESP32-CAM
Real-time Video Streaming
Android App Control
Wi-Fi Communication
Remote Surveillance
Servo Motor
Control Robot Navigation

Abstract

This paper presents an IoT-based surveillance Robot designed for hazardous environment monitoring. The system utilizes two ESP32-CAM modules: one for real-time video streaming and another for Robot control via a mobile application. The Robot is manually operated through an Android app, which connects to the ESP32-CAM over WiFi. The app stores Wi-Fi credentials and IP addresses using Room Database, enabling easy reconnection. The surveillance system supports live streaming in both day and night conditions and includes servo motor-based camera movement for improved visibility. Additional features include manual navigation controls, flashlight toggling for low-light environments, and remote operation capabilities. This system reduces human intervention in dangerous areas, enhancing safety and security. Future enhancements could extend its application to defense and mining operations, where continuous surveillance is critical.

Introduction

Surveillance in hazardous environments is a crucial aspect of security and safety. Traditional monitoring methods often expose human personnel to dangerous conditions. To address this challenge, IoT-based surveillance Robots offer an efficient and remote monitoring solution. This project presents an IoT-Based Surveillance Robot that utilizes two ESP32-CAM modules—one for real-time video streaming and another for controlling the robot's movement via a mobile application.

The system operates over Wi-Fi communication, enabling remote access through an Android app. The app allows users to input WiFi credentials, store them in a Room Database, and retrieve the ESP32-CAM's IP address for seamless connection. The video streaming module provides live surveillance, while the control module enables manual bot navigation using a L298N motor driver and gear motors.

Additionally, servo motors allow camera movement for improved visibility, and a flashlight toggle enhances night-time monitoring. The proposed Robot reduces human intervention in risky environments, making it ideal for applications such as border surveillance, disaster zones, and industrial safety monitoring. Future advancements could further integrate AI-based object detection and autonomous navigation for enhanced functionality

LITERATURE SURVEY

In [1], G. Anandravisekar, A. Anto Clinton, T. Mukesh Raj, L. Naveen, and M. Mahendran developed an IoT-based surveillance robot aimed at domestic area monitoring. The robot utilizes an Arduino microcontroller to control its movements and capture environmental data.

Users can operate the robot remotely via a mobile application, enabling real-time audio and video surveillance. This system enhances security by reducing human intervention in potentially hazardous environments.

In [2], T. Akilan, Satyam Chaudhary ,Princi Kumari ,Utkarsh Pandey introduced a surveillance robot designed for hazardous environments. The robot is equipped with sensors to detect toxic gases like carbon monoxide and features metal detection capabilities. Additionally, it provides precise location tracking via GPS. The system employs an Arduino microcontroller and interfaces with an Android smartphone, leveraging the smartphone's hardware for video capture and communication, thereby reducing overall system costs.

In [3], Ansh Dudeja, Anshul Yadav, Anveshak Parashar, Arnay Kabtiyal, and Shaveta Arora proposed an IoT-based surveillance robot for monitoring domestic areas. The robot integrates various sensors and utilizes an Arduino microcontroller for control. Users can remotely operate the robot via a mobile application, enabling real-time audio and video surveillance.

In [4], B. Lakshmanaprakash and P. Rajalakshmy proposed an IoT-based autonomous outdoor patrol robot designed to assist police or security guards in performing dynamic, remote, and autonomous surveillance during both day and night. The compact, omni-directional robot is equipped with a highdefinition camera that provides real-time live streaming, which can be monitored and controlled remotely via a customized operator console or mobile devices. This system enhances surveillance capabilities in various environments.

In [5], 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 war field 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.

SYSTEM HARDWARE

The IoT-based surveillance Robot consists of various hardware components that work together to enable real-time monitoring, remote navigation, and efficient operation. The key hardware components include:

ESP32-CAM

An ESP32-CAM is a low-power, compact Wi-Fi-enabled module that integrates an ESP32-S microcontroller with an inbuilt OV2640 camera module. It supports real-time video streaming and image capturing, making it suitable for surveillance applications. The module includes built-in flash memory, Wi-Fi capabilities, and a microSD card slot for data storage. With GPIO pins available, it allows interfacing with additional components like LED flash and sensors. The ESP32-CAM is programmed using the Arduino IDE and can communicate wirelessly with an Android application for remote monitoring and control. Fig. 1 shows the ESP32-CAM module .

Fig1. ESP32-CAM

L298N motor driver

The L298N motor driver is a dual H-Bridge driver module used to control the direction and speed of DC motors. It allows bidirectional control of two motors simultaneously using PWM signals. The module operates within a voltage range of 5V to 35V and can handle a peak current of 2A per channel. It has an onboard voltage regulator, which provides stable power to the control logic. This motor driver plays a crucial role in moving the surveillance Robot in different directions based on user input from the Android app. Fig. 2 shows the L298N motor driver module.

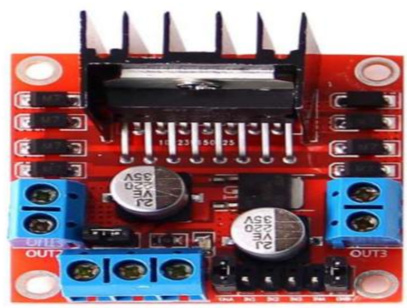


Fig. 2. L298N MOTOR DRIVER

C.Gear Motors

Gear motors are used to drive the Robot, ensuring stable and efficient movement across different surfaces. These DC motors are equipped with a gear reduction mechanism, which decreases the motor speed while increasing torque, making them suitable for precise movement control. The gear motors are connected to the L298N motor driver, allowing the Robot to move forward, backward, left, and right as per the commands received from the Android application. These motors operate on DC voltage and provide smooth navigation, enabling the Robot to function effectively in surveillance applications. Fig. 3 shows the gear motor used in the surveillance Robot.

Fig 3. GEAR MOTOR

D.Servo Motors

Servo motors are used to control the camera movement for better surveillance coverage. The Robot includes two servo motors, one for vertical movement (up and down) and another for horizontal movement (left and right). The PWM(Pulse Width Modulation), a technique used to control the power delivered to electrical devices. Which controlled motors allow precise angle adjustments, ensuring flexible positioning of the camera to capture a wider field of view. The servo motors receive signals from the Arduino Uno, which adjusts their angles based on user input from the Android application. This functionality enhances surveillance efficiency, providing better coverage of the monitored area. Fig. 4 illustrates the servo motor used in the Robot.

Fig 4. SERVO MOTOR

E.12-Volt Adapter

The IoT-based surveillance Robot is powered by a 12-volt power supply that provides consistent energy to the ESP32-CAM modules, motors, and sensors. This power supply ensures stable operation for continuous video streaming and Robot control, making it ideal for environments where a fixed power source is available. The 12-volt power adapter guarantees reliability and supports long-duration operation without the need for frequent recharging.

Fig 5. 12-Volt Adapter

F.Lithium-Ion battery

The surveillance Robot is powered by a Lithium-Ion (Li-Ion) battery, providing a power source for the ESP32-CAM modules, L298N motor driver, and motors. It offers high energy density, lightweight design, and long lifespan. The battery ensures consistent power delivery and includes built-in protection against overcharging and overheating.

Fig 6. 11.2v Lithium Ion Battery

SOFTWARE SPECIFICATION

The development of the IoT-based surveillance Robot involves two key software components: Android Studio for the mobile application and Arduino IDE for programming the ESP32-CAM modules.

Android Studio-

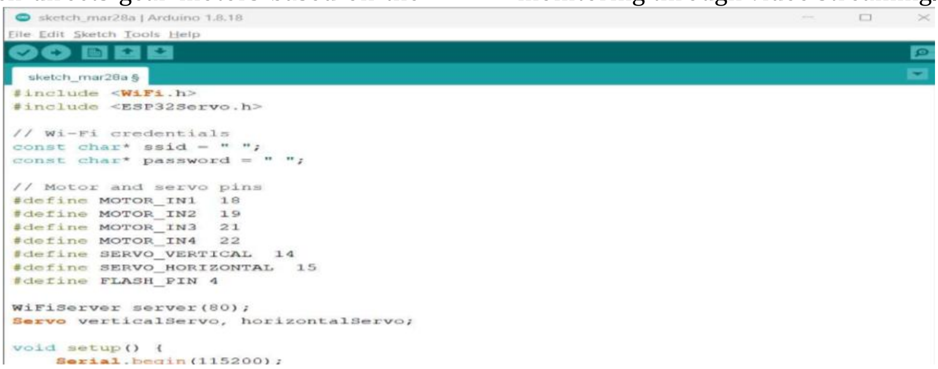
1)Android Studio is used to develop two separate Android applications. The first application is responsible for video streaming, allowing users to enter Wi-Fi credentials, connect to the ESP32-CAM, and retrieve its IP address. It also features a capture button to request a snapshot and stores the Wi-Fi SSID, password, and IP address in a Room Database for future use.

2)The second application is used for Robot control, where users can connect to the ESP32-CAM and send movement commands such as forward, backward, left, and right. Additionally, the app includes sliders for adjusting servo angles (vertical and horizontal) to control the camera's orientation and a flashlight toggle button to enable the ESP32 CAM's LED flash in low-light environments.

Communication between the Android application and the ESP32-CAM modules is achieved through HTTP requests over Wi-Fi, ensuring real-time control and monitoring.

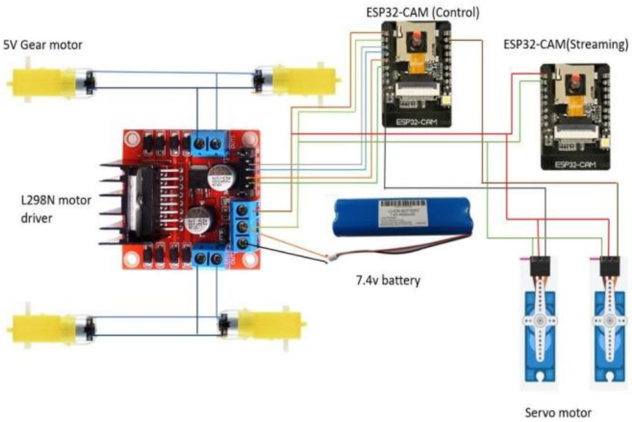
Arduino IDE-

The ESP32-CAM modules are programmed using Arduino IDE in C++. One ESP32-CAM is dedicated to video streaming, handling Wi-Fi connectivity and streaming live footage to the mobile application. The second ESP32-CAM is responsible for Robot control, where it receives HTTP commands from the Android app and executes corresponding actions. The Robot's movement is controlled using an L298N motor driver, which directs gear motors based on the received commands. Additionally, servo motors are used to adjust the camera's position, providing flexible surveillance angles. A flashlight control mechanism is implemented to enable or disable the ESP32-CAM's LED light as required. The firmware ensures smooth and reliable operation, allowing the surveillance Robot to navigate efficiently in hazardous environments while providing continuous monitoring through video streaming.



SYSTEM ARCHITECTURE

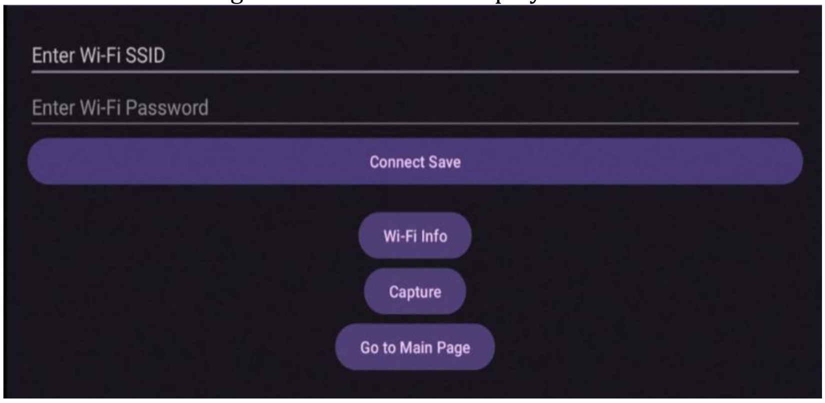
The system architecture consists of two main components: the ESP32-CAM 1 and ESP32-CAM 2, which serve different functions in the surveillance Robot system. ESP32-CAM 1 is responsible for video streaming, capturing and transmitting live video to the Android app through Wi-Fi. ESP32-CAM 2 handles the control of the Robot's movement, interfacing with the L298N motor driver to control the four gear motors for navigation, and servo motors for adjusting the vertical and horizontal camera angles. The Robot is powered by a 12W adapter instead of a lithium ion battery. Communication between the two ESP32-CAM modules and the Android application occurs over a shared Wi-Fi network. The Android Application (App 1 and App 2) plays a critical role in both video streaming and Robot control. App 1 allows the user to input Wi-Fi credentials and connect to the ESP32CAM 1, enabling video streaming. App 2 enables the user to control the Robot's movements (forward, backward, left, right) and adjust the vertical and horizontal servo motors via buttons and sliders. The app stores Wi-Fi credentials and the IP addresses of the ESP32-CAM modules in a Room database, ensuring easy connection management. By enabling real-time video streaming and remote Robot control through Wi-Fi, the system provides an effective solution for continuous surveillance in hazardous environments, reducing the need for direct human intervention.



IMPLEMENTATION

1. The first app (Video Streaming Interface) provides a simple interface for connecting to the Robot's camera and viewing the live video stream. Users are prompted to enter the Wi-Fi SSID and password in dedicated text fields, which are then stored in the Room database. A "Connect and Save" button is provided for saving the credentials and establishing a connection with the Robot. There is also a "WiFi Info" button that displays the stored Wi-Fi details, including the SSID, password, and the IP address of the ESP32-

CAM module used for streaming. Once connected, users can click on the "Capture" button to request the IP address for video streaming from the ESP32-CAM, and the "Main Page" button takes the user to the page where the video stream is displayed.



2. The second app (Robot Control Interface) is designed for controlling the movement and camera angles of the Robot. The interface includes a "Capture IP" button, which retrieves the Robot's IP address for communication. A "Toggle Flashlight" button allows users to enable or disable the flashlight on the ESP32-CAM for improved visibility in dark environments. For navigation, the app includes buttons to move the Robot forward, backward, left, and right. Additionally, there are two sliders to control the vertical and horizontal angles of the camera, allowing the user to adjust the camera's position both vertically (up and down) and horizontally (left and right) with specific angle adjustments. This design ensures users can easily manage both the surveillance feed and Robot movement in real-time.

Comparative Analysis of Hardware Component

Component	Why we choose this	Alternative	Why it wasn't chosen
ESP32-CAM vs Arduino Uno	The ESP32CAM integrates a Wi-Fi module, Bluetooth, and a camera for video streaming, making it ideal for IoTbased surveillance with minimal additional components.	Arduino Uno	The Arduino Uno lacks builtin Wi-Fi/Bluetooth And video streaming support, requiring extra components and increased complexity.
Wi-Fi Module vs Bluetooth Module	The Wi-Fi Module offers longer range, better data transfer speeds, and remote access capabilities, ideal for video streaming	Bluetooth Module	Bluetooth has a limited range and lower data transfer speed, making it unsuitable for long-distance communication and video streaming.

CONCLUSION AND FUTURE SCOPE

In conclusion, the IoT-based surveillance Robot successfully integrates real-time video streaming and remote control, offering an efficient solution for monitoring hazardous environments. Powered by two ESP32-CAM modules and a 12W power supply, the Robot provides seamless operation through Wi-Fi communication and an intuitive Android app interface. It effectively reduces the need for human intervention in dangerous environments by providing reliable surveillance in both well-lit and low-light conditions. The system's design ensures stable power supply, efficient movement control, and high-quality video streaming, making it a versatile tool for realtime monitoring.

Looking ahead, several enhancements can be made to expand the Robot's capabilities. One promising area for future development is the integration of AI-based object recognition, which would allow the Robot to automatically detect and track specific objects or individuals in its environment. With these improvements, the Robot could play an even more significant role in industries such as security, and environmental monitoring, providing enhanced capabilities for hazardous area surveillance.