

## Smart IoT Surveillance Robot for Live Monitoring Using ESP32-CAM Module

Allanki Sanyasi Rao<sup>1</sup>, K Radha<sup>2</sup>, G Gayathri<sup>3</sup>, K Abhinay<sup>4</sup>, N Anji reddy<sup>5</sup>, Bharath<sup>6</sup>

<sup>1</sup>Associate Professor, <sup>2,3,4,5,6</sup> UG Student, Dept. of Electronics & Communication Engg.

Christu Jyothi Institute of Technology & Science, Jangaon, Telangana, India

### Abstract

Modern surveillance systems require reliable monitoring solutions that can operate in hazardous or hard-to-reach environments. Conventional methods often depend on human involvement, which can pose safety risks. This work presents an IoT-based surveillance robot using the ESP32-CAM module for remote monitoring applications. The system combines a robotic platform with a wireless camera module capable of real-time video streaming. DC motors, controlled through a motor driver, enable movement in multiple directions. The ESP32-CAM module supports image capture and Wi-Fi communication, allowing live video transmission to a remote user via a web interface. This setup enables monitoring of restricted or high-risk areas from a safe distance. Wireless control through a mobile device or computer allows real-time navigation and observation. The system offers a cost-effective, portable, and efficient solution for applications such as security surveillance, border monitoring, and disaster management.

**Keywords:** IoT surveillance robot, ESP32-CAM module, real-time video streaming, wireless monitoring, remote navigation, security surveillance.

### 1 Introduction

The IoT-based surveillance robot is an intelligent monitoring system developed to improve security in hazardous or restricted environments [8][10]. Modern defense and security operations require continuous observation of sensitive areas such as border regions, conflict zones, and disaster-affected locations where human presence may be unsafe. Conventional surveillance approaches rely on manual patrols or fixed camera systems, which often provide limited coverage and may expose personnel to risks [1]. By combining robotics, wireless communication, and Internet of Things (IoT) technology, this system

enables remote monitoring and real-time observation without direct human involvement [2][11]. The robot is equipped with a camera module and wireless connectivity, allowing operators to view surroundings and control movement from a safe distance.

A key feature of the system is real-time visual surveillance. The ESP32-CAM module integrates a microcontroller with a camera capable of capturing images and streaming live video over a wireless network [4][12]. Through Wi-Fi connectivity, the video feed is transmitted to a smartphone or computer interface, enabling continuous observation of the monitored area. This feature is especially useful in situations requiring immediate awareness, such as detecting suspicious activity or identifying potential threats in restricted locations. Mobility plays an important role in effective monitoring. The robot is built on a movable platform driven by DC motors, which are controlled using an L298N motor driver module [6]. This setup allows movement in multiple directions, including forward, backward, left, and right. Commands can be sent wirelessly, enabling real-time navigation and precise positioning within the environment. This capability allows coverage of larger areas compared to stationary surveillance systems.

Wireless communication and IoT integration further enhance system functionality. The ESP32 microcontroller supports Wi-Fi connectivity, enabling communication between the robot and the remote user interface [12]. Sensor data and video streams are transmitted over the network, while control commands are received from the user. A web-based or mobile interface can be used to monitor and operate the system, making it flexible and easy to deploy in different scenarios without complex infrastructure [3][7]. The system is powered by rechargeable 18650 lithium batteries, which provide sufficient energy for both the motors and the camera module. These batteries are known for their high energy density, compact size, and longer operational life, making them suitable for portable robotic systems. Efficient power usage ensures that the robot can function for extended periods during surveillance tasks. The combination of camera-based monitoring, wireless communication, and robotic mobility makes the system suitable for a wide range of applications. In defence scenarios, it can be used for reconnaissance and monitoring in high-risk areas. In disaster management, it can assist in inspecting damaged structures or locating individuals in unsafe conditions. Industrial environments can also benefit by using such systems to monitor hazardous zones or restricted areas [10].

This IoT-based surveillance robot highlights the effective use of embedded technologies in creating a reliable and cost-efficient monitoring solution. Real-time video streaming, remote control, and wireless communication contribute to improved safety and operational efficiency. The integration of IoT and robotics enhances surveillance capabilities and supports secure monitoring in challenging environments [8][11].

## 2 Existing System

Conventional surveillance systems mainly depend on fixed cameras or manual observation [1]. Although these methods offer basic security monitoring, they face several challenges when applied in dynamic or hazardous environments. Stationary cameras remain limited to a specific location and cannot efficiently cover large areas. In defense or security scenarios, manual patrols are often required to supervise restricted zones, which can put personnel at risk. In addition, many traditional systems rely on wired communication, which restricts mobility and reduces flexibility in deployment.

Some robotic surveillance solutions have been introduced to address these issues, but they often involve costly components and complex setups. Many of these systems also face challenges such as limited communication range and increased power consumption. These drawbacks emphasize the need for a portable, cost-effective, and wireless surveillance system that supports real-time monitoring and remote operation [2][10].

## 3 Proposed Approach

The proposed IoT-based surveillance robot is designed as a mobile monitoring system capable of capturing and transmitting real-time video from remote or inaccessible locations [11]. The system is composed of essential components including the ESP32 microcontroller, ESP32-CAM module, motor driver module, DC motors, and a battery power supply. The ESP32 microcontroller serves as the central control unit, responsible for receiving commands from the user through Wi-Fi communication and processing them to control the robot's movement and overall operation [12].

The ESP32-CAM module plays a crucial role by capturing images and streaming live video of the surrounding environment [4]. This video data is transmitted wirelessly to a remote device such as a smartphone or laptop, enabling continuous monitoring. The motor

driver module acts as an interface between the microcontroller and the DC motors, allowing the robot to move in various directions such as forward, backward, left, and right based on user commands [6]. The battery power supply ensures uninterrupted operation by providing the required energy to all components, making the system portable and suitable for real-time surveillance applications.

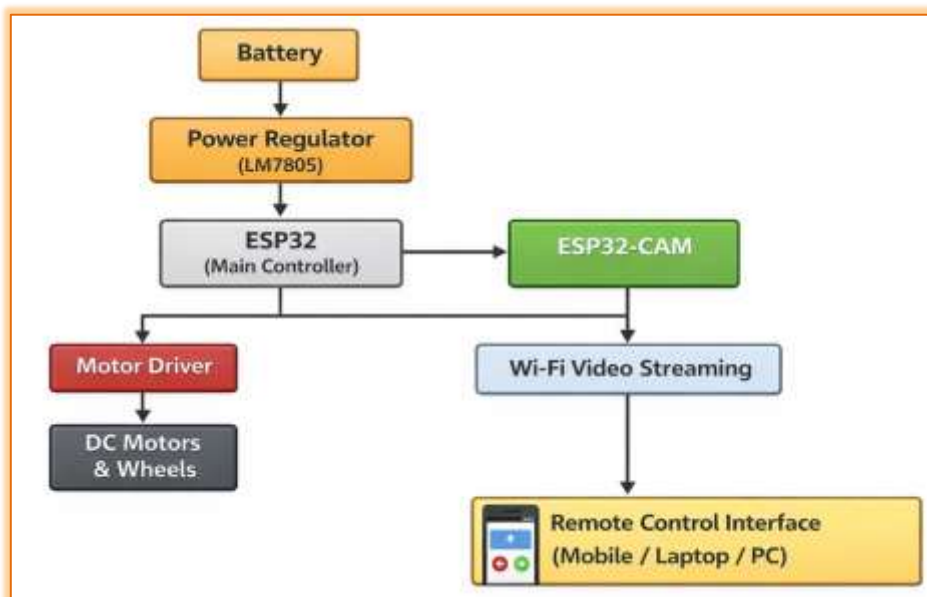


Figure 1: Block Diagram of the Proposed System

## 4 Results and Discussions



Figure 2: Experimental Setup

The developed IoT-based surveillance robot was implemented and tested under controlled conditions to evaluate monitoring capability, wireless communication, and mobility. The system, built using an embedded microcontroller, camera module, motor driver, and rechargeable power supply, showed reliable performance in real-time video capture, wireless data transmission, and response to remote commands. The ESP32-CAM module enabled live video streaming over Wi-Fi with minimal delay, allowing clear observation of the surroundings. The DC motors, controlled through the L298N driver, provided smooth and stable movement in multiple directions with consistent response to user inputs. Wireless communication remained stable within short-range environments, supporting simultaneous video transmission and control.

Continuous video streaming allowed effective remote observation of objects and movement. The robot demonstrated efficient navigation on flat surfaces, while the battery system ensured stable power supply during operation. The system proved suitable for mobile surveillance applications, though it is limited by Wi-Fi range and network stability. Overall, it offers a reliable and cost-effective solution for real-time remote monitoring.

## 5 Conclusion

The IoT-based surveillance robot using ESP32-CAM offers a compact and efficient solution for remote monitoring applications. By combining IoT communication, camera-based observation, and robotic mobility, the system allows safe monitoring of hazardous environments without exposing personnel to danger.

The developed prototype shows that low-cost embedded systems can be effectively utilized to create intelligent surveillance robots. It successfully enables live video streaming along with remote navigation through wireless communication. This technology can be applied in areas such as defense surveillance, border security, disaster management, and industrial monitoring. With further enhancements like long-range communication, AI-based navigation, and additional sensing capabilities, it can evolve into a more advanced autonomous surveillance system.

## REFERENCES

- [1]. A. Gasparetto and L. Scalera, "From the Unimate to the Delta Robot: The Early Decades of Industrial Robotics," in *Explorations in the History and Heritage of Machines and Mechanisms*, Springer, Cham, 2019.
- [2]. K. Ashton, "That 'Internet of Things' Thing," *RFID Journal*, vol. 22, no. 7, pp. 97–114, 2009.
- [3] Allanki Sanyasi Rao., et al., Exploring the Potential of IoT: An In-Depth Examination of Applications and Prospects., *Journal of Contemporary Issues in Business and Government*, Vol. 29, Issue 3, Oct 2023, P-ISSN: 2204-1990; E-ISSN: 1323-6903, Pages: 49-67, DOI: 10.48047/cibgp.2023.29.04.004
- [4] Espressif Systems, *ESP32-CAM Technical Reference Manual*, Espressif Systems, 2020.
- [5]. Arduino, "Arduino IDE User Guide," Available: <https://www.arduino.cc>
- [6]. Texas Instruments, *L298N Dual H-Bridge Motor Driver Datasheet*, Texas Instruments, 2016.
- [7] Allanki Sanyasi Rao., et al., "Navigating the Internet of Things (IoT): Towards a Smart and Sustainable Future-Opportunities, Issues and Challenges" in an *International Journal of Early Childhood Special Education*, ISSN: 1308-5581, Vol.: 1, Issue: 04, July 2023, Pages: 20-31, DOI:10.48047/INTJECSE/V15I4.4,
- [8]. S. Madakam, R. Ramaswamy, and S. Tripathi, "Internet of Things (IoT): A Literature Review," *Journal of Computer and Communications*, vol. 3, no. 5, pp. 164–173, 2015.
- [9]. M. Patel and J. Wang, "Applications, Challenges, and Prospective in Emerging Body Area Networking Technologies," *IEEE Wireless Communications*, vol. 17, no. 1, pp. 80–88, 2010.
- [10]. L. Da Xu, W. He, and S. Li, "Internet of Things in Industries: A Survey," *IEEE Transactions on Industrial Informatics*, vol. 10, no. 4, pp. 2233–2243, 2014.
- [11]. J. Stankovic, "Research Directions for the Internet of Things," *IEEE Internet of Things Journal*, vol. 1, no. 1, pp. 3–9, 2014.
- [12]. Espressif Systems, *ESP32 Series Datasheet*, Espressif Systems, 2021.