iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 12 **Issue:** III **Month of publication:** March 2024

DOI: https://doi.org/10.22214/ijraset.2024.59581

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue III Mar 2024- Available at www.ijraset.com

IoT-Based Wireless Surveillance Robot: Enhanced Control and Real-Time Video Streaming for Espionage and Security Applications

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Abstract: ***In the current era of technological advancements, ensuring security and surveillance has become a top priority. The integration of the Internet of Things (IoT) and robotics technology has In paved the way for the development of an IoT-based surveillance robot, which serves as an efficient, reliable, and intelligent security system. This paper presents the design, implementation, and evaluation of such a robot, highlighting its various features and capabilities.***
The IoT-based surveillance robot is equipped with a range of sensors, including ultrasonic, motion, temperature, and humidity sensors, enabling it to detect intrusions, monitor environmental conditions, and alert the relevant authorities in case of any irregularities. The system incorporates wireless communication protocols like Wi-Fi and Zigbee, facilitating remote monitoring and control via a user-friendly web interface and smartphone application.
The proposed system is tested and evaluated in real-life scenarios, such as homes, offices, and public spaces, demonstrating its potential to enhance security and surveillance efforts. The findings of this research contribute towards the development of a secure, automated, and interconnected future through the synergy of IoT and robotics technologies.
Keywords: Robotics Technology, surveillance, Internet of things.

I. INTRODUCTION

In recent years, the ever-evolving landscape of technology has witnessed a remarkable transformation in the field of security and surveillance systems. With the advent of the Internet of Things (IoT), the concept of interconnected devices has revolutionized various industries, including home automation, industrial control, and monitoring systems. The fusion of IoT and robotics has led to the development of innovative solutions, such as IoT-based surveillance robots, which have the potential to redefine the way security is managed in residential, commercial, and public spaces.

IoT-based surveillance robots are smart, autonomous devices designed to detect intrusions, monitor environmental conditions, and alert authorities in case of emergencies. These robots are equipped with various sensors, such as ultrasonic, motion, temperature, and humidity sensors, enabling them to gather real-time data and transmit it wirelessly to a remote server or cloud platform. This allows users to access the information through a web interface or smartphone application, facilitating remote monitoring and control. The aim of this paper is to present the design, implementation, and evaluation of an IoT-based surveillance robot. The paper highlights the system's hardware components, software architecture, and communication protocols, emphasizing the system's ability to enhance security and surveillance efforts. The paper also discusses the potential applications and benefits of the proposed system in various domains, including homes, offices, and public spaces. Finally, the paper examines the system's performance in real-life scenarios, demonstrating its effectiveness and efficiency in providing a secure and reliable monitoring solution.

Overall, the development of IoT-based surveillance robots represents a significant advancement in the field of security and surveillance systems. These intelligent and interconnected devices offer numerous advantages over traditional systems, paving the way for a safer and more secure future.

II. RELATED WORK

1) Design of an IoT based smart surveillance robot for industrial applications" by R. Lakshmi Narayanan, S. Sreejith, M.L. Dhanya, and P.C. Hema (2018). This "research focuses on the design and implementation of an IoT-based surveillance robot for industria: l applications, integrating various sensors and wireless communication technologies.

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2) "Surveillance Robot for Firefighting Based on IoT" by Rajkumar Kshirsagar, Suraj Chavhan, and Prakash Shende (2017). This work proposes a firefighting surveillance robot that utilizes IoT technology for real-time monitoring and control, helping to reduce risks for human firefighters.
3) "Design of Surveillance Robot for Home and Industrial Automation" by Prateeksha K. Salunkhe and Akshay M. Baviskar (2016). This paper presents a surveillance robot designed for home and industrial automation, employing IoT and wireless communication technologies for remote monitoring and control.
4) "Real-Time Monitoring and Control System for Surveillance Robot Based on IoT Technology" by Sheng Wang, Xijun Zhang, Yong Wang, and Jing Yang (2017). This research focuses on the development of a real-time monitoring and control system for a surveillance robot, leveraging IoT technology for improved efficiency and performance.
5) "IoT Based Autonomous Surveillance and Night Patrolling Robot for Home Security" by Ayush Agarwal and Shashank Singh (2018). This work proposes an autonomous surveillance robot for home security, using IoT technology to enable remote monitoring, object detection, and intruder alert features.

III. METHODOLOGY

The methodology for implementing the IoT-based wireless surveillance robot begins with the design and integration of hardware components such as the AI Thinker ESP32CAM module, motor drivers, batteries, and wheels to form a functional surveillance platform. Subsequently, software development entails programming the ESP32CAM module to capture and stream video, implementing motor control algorithms, and creating a user interface for remote control via a web browser. Wi-Fi connectivity is established, and network infrastructure is configured to facilitate communication between the surveillance robot and user devices. A user-friendly web interface is developed, featuring controls for movement and live video streaming display. Rigorous testing is conducted to validate the system's functionality, including video streaming performance, control mechanisms, and overall stability. Optimization efforts are employed to enhance system performance and efficiency, followed by deployment for practical use in espionage and security applications. Real-world evaluation assesses the system's effectiveness, reliability, and suitability for various surveillance tasks, with feedback informing further refinements and improvements.

IV. BLOCKDIAGRAM

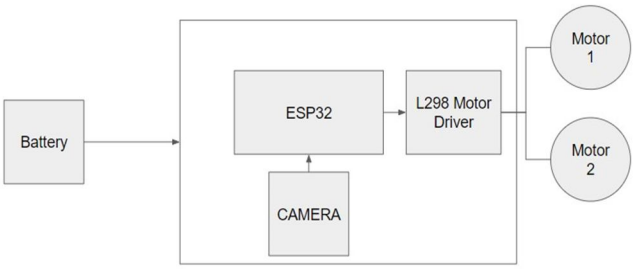


Fig.1 Block Diagram of the System

V. CIRCUIT DIAAGRAM

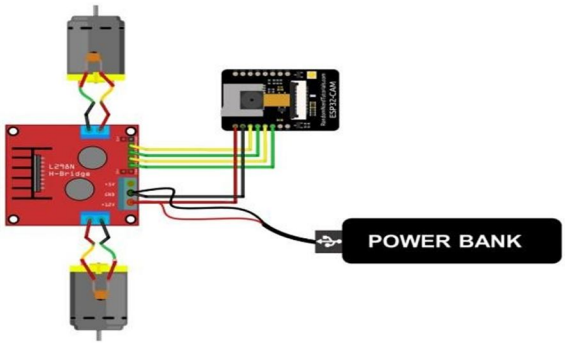


Fig. 2.1

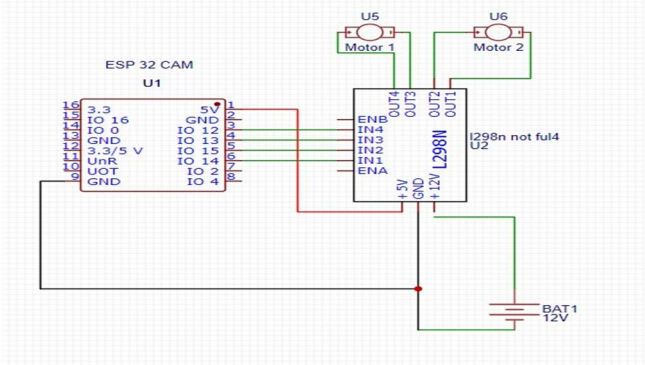


Fig. 2.2

VI. COMPONENTS

A. *Motor Driver*



Fig. 3 Motor Driver

The motor driver serves as a pivotal component in the IoT-based wireless surveillance robot, facilitating precise control over the movement of the device. Its primary functions encompass direction control, enabling the robot to move forward, backward, left, and right by modulating the polarity of the voltage supplied to the motors. Additionally, the motor driver often integrates speed control mechanisms, regulating motor velocity through pulse-width modulation techniques. This functionality ensures the robot's ability to navigate diverse environments with varying speeds. Furthermore, the motor driver incorporates safety features such as current limiting and overload protection, safeguarding the motors against damage from excessive current draw and electrical faults. In operation, the motor driver receives control signals from the microcontroller or control circuitry, translates them into appropriate voltage levels, and delivers them to the motors, thereby enabling precise and reliable movement control essential for effective surveillance and security applications.

B. *ESP32-CAM*



Fig. 4 ESP32 Camera

The ESP32 Camera module, a key component in the IoT-based wireless surveillance robot, serves multiple functions critical to its operation. Firstly, it functions as the primary image capture device, equipped with an OV2640 camera sensor capable of capturing high-resolution images and video footage. The camera module interfaces with the ESP32-S processor, facilitating seamless integration with the robot's control system. Additionally, the camera module incorporates a microSD card slot, enabling the storage of captured images and video locally for later retrieval or analysis. Moreover, the ESP32 Camera module supports real-time video streaming capabilities, leveraging the HTTP communication protocol to transmit live video feed to remote devices such as smartphones or web browsers. In operation, the camera module captures images or video footage, processes the data using the ESP32-S processor, and transmits it over Wi-Fi for remote viewing or storage, thereby providing essential visual surveillance capabilities for the robot in espionage and security applications.

C. Lithium Battery



Fig. 5 Lithium Battery

The lithium battery serves as the power source for the IoT-based wireless surveillance robot, supplying electrical energy to drive its various components and facilitate extended operation. The primary function of the lithium battery is to store and deliver electrical energy efficiently to power the robot's motors, microcontroller, camera module, and other electronic devices. Lithium batteries are favored for their high energy density, lightweight, and long cycle life, making them ideal for portable applications like the surveillance robot.

The working principle of the lithium battery involves electrochemical reactions within its cells. During charging, lithium ions move from the positive electrode (cathode) to the negative electrode (anode), where they are stored in the anode material. Conversely, during discharging, the lithium ions flow back to the cathode, generating electrical energy that powers the connected devices. The voltage and current output of the battery are regulated by the battery management system (BMS) to ensure safe and efficient operation.

In operation, the lithium battery provides the necessary power to drive the surveillance robot, enabling it to move, capture images, stream video, and perform other functions essential for espionage and security applications. Proper charging and management of the lithium battery are crucial to maximize its lifespan and ensure reliable performance of the surveillance robot.

D. DC Dual Shaft Motor



Fig. 6 DC BO Dual Shaft motor

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 12 Issue III Mar 2024- Available at www.ijraset.com

The DC BO Dual Shaft motor is a critical component of the IoT-based wireless surveillance robot, serving the primary function of propelling the robot's movement. These motors feature dual shafts, enabling the attachment of wheels or other mechanical components for enhanced functionality. The working principle of the DC BO Dual Shaft motor involves converting electrical energy into mechanical motion through electromagnetic induction. When a voltage is applied to the motor terminals, it generates a magnetic field that interacts with the permanent magnets within the motor, causing the rotor to rotate. This rotational motion is transferred to the wheels or other attached components, propelling the robot forward, backward, or in other desired directions. The speed and direction of the motor can be controlled by varying the voltage and polarity of the applied electrical signals. In the surveillance robot, these motors are typically paired with motor drivers to regulate their speed and direction effectively, allowing for precise control over the robot's movement during surveillance and security operations.

VII. WORKING

The enhanced control and real-time video streaming system for espionage and security applications with an IoT-based wireless surveillance robot operate through a combination of hardware and software components working in tandem. Firstly, the surveillance robot's hardware, including the motor drivers, DC motors, camera module, and lithium battery, is integrated and powered up. The ESP32CAM module captures high-resolution images and video footage, which are processed by the ESP32-S processor. The system utilizes Wi-Fi connectivity to transmit live video streams to remote devices, such as smartphones or web browsers, through the HTTP communication protocol. Meanwhile, the motor drivers receive control signals from the user interface, allowing for precise control over the robot's movement. Users can remotely access the web interface to steer the robot and view real-time video feeds, facilitating surveillance tasks in espionage and security scenarios. This synchronized operation enables users to remotely control the robot's movement while simultaneously monitoring its surroundings in real-time, providing an effective solution for surveillance and security applications.

VIII. EXPERIMENTAL RESULTS

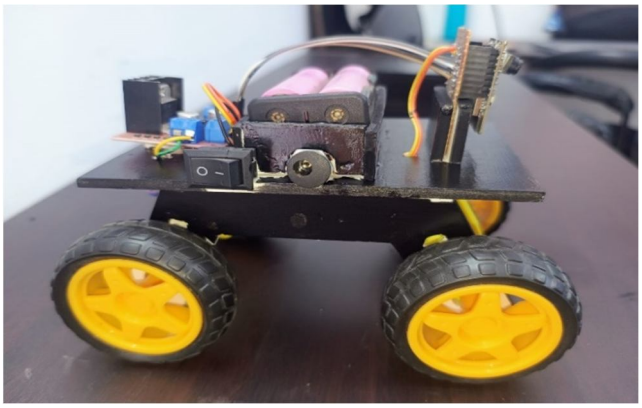


Fig. 7 Espionage Robot

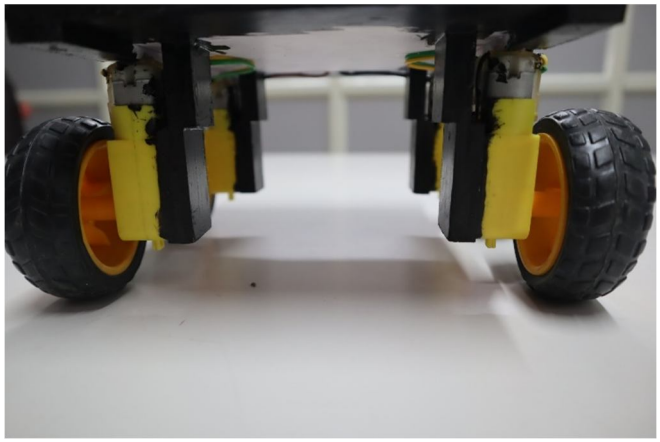


Fig. 8 DC Motor

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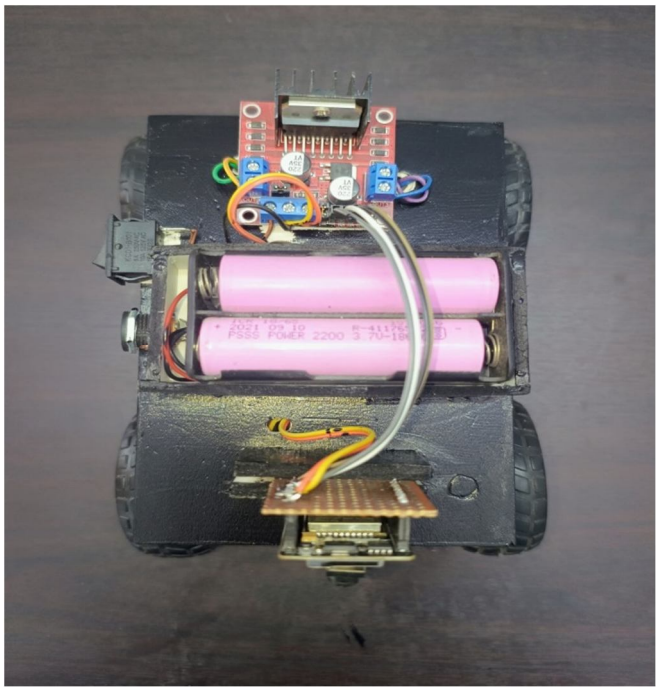


Fig. 9 Motor driver & batteries

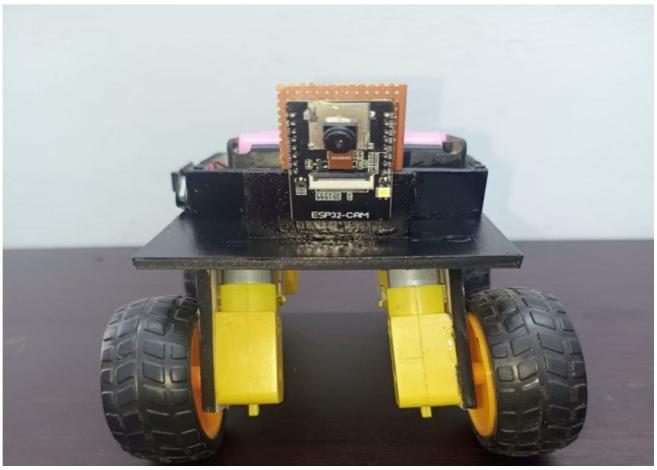


Fig .10 ESP 32- CAM

IX. ADVANTAGES

1) *Versatility:* These robots are highly adaptable and can be deployed in various scenarios and locations to provide tailored surveillance coverage, particularly useful in dynamic environments requiring rapid responses.
2) *Remote Control:* Operators can remotely control these robots using wireless communication links such as Wi-Fi or cellular networks, enabling real-time monitoring and control from a safe distance, reducing the need for human presence in hazardous areas.
3) *Continuous Monitoring:* Equipped with cameras, sensors, and monitoring devices, wireless surveillance robots ensure round-the-clock surveillance without breaks or shifts, enhancing security with uninterrupted monitoring capabilities.
4) *Cost Efficiency:* Offering long-term cost savings, these robots minimize the need for human intervention in maintenance and operation, while efficiently covering large areas, thus enhancing the cost-effectiveness of security operations.
5) *Safety Enhancement:* Wireless surveillance robots contribute to overall safety and security by supplementing or replacing human guards in hazardous environments. Equipped with sensors, they can detect threats such as fires, gas leaks, or intruders, enabling prompt responses to potential dangers.

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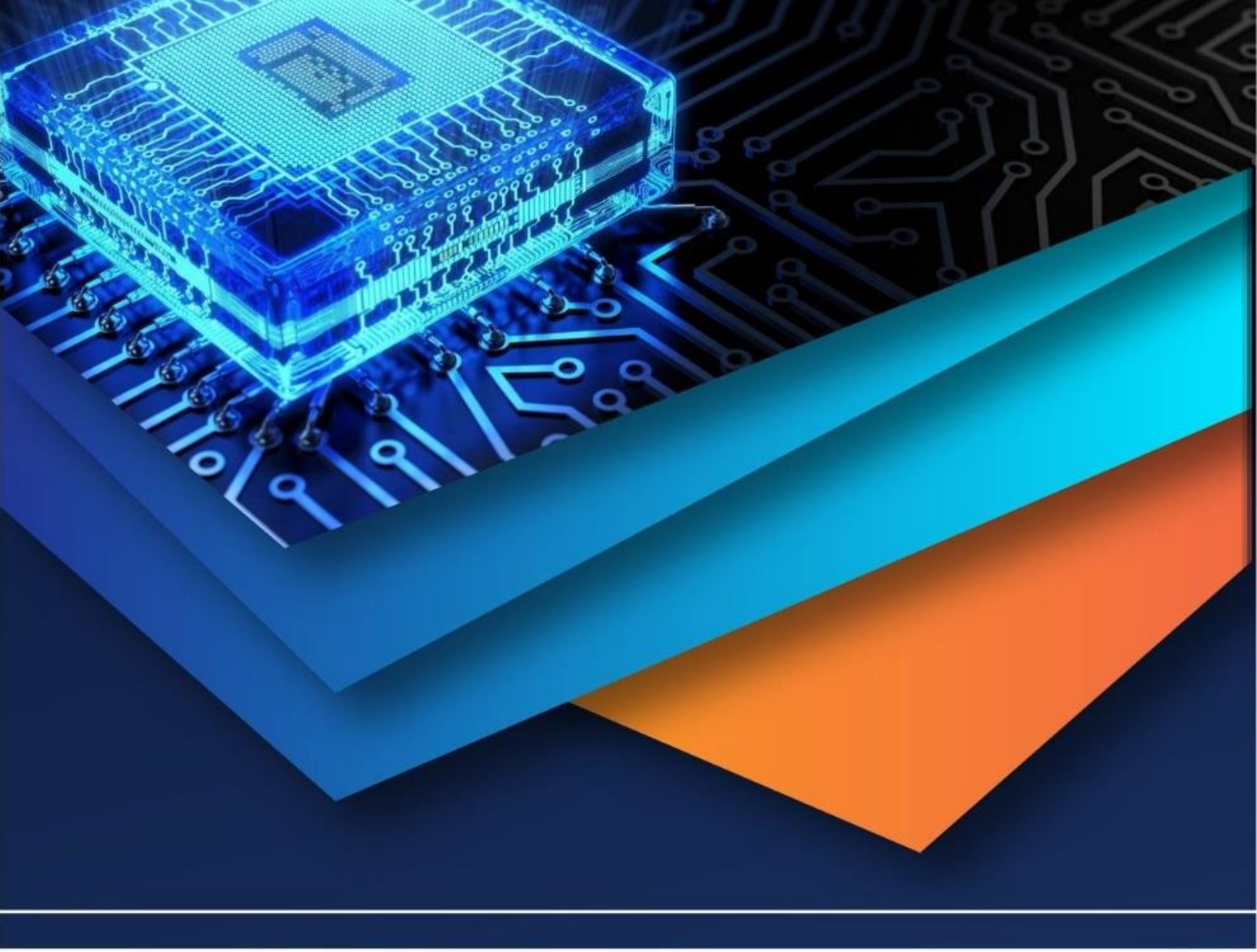
X. CONCLUSION

In conclusion, the implementation of enhanced control and real-time video streaming for espionage and security applications with an IoT-based wireless surveillance robot represents a significant advancement in surveillance technology. By integrating hardware components such as motor drivers, DC motors, and a camera module with software functionalities for remote control and live video streaming, the system offers unparalleled capabilities for monitoring and safeguarding various environments. The ability to remotely control the robot's movement and view live video feeds in real-time provides users with enhanced situational awareness and flexibility in surveillance operations. Moreover, the discreet and portable nature of the surveillance robot makes it well-suited for espionage and covert security applications. Overall, the system's effectiveness, cost-effectiveness, and scalability make it an asset for addressing the evolving security challenges faced by modern organizations and institutions. As technology continues to advance, the IoT-based wireless surveillance robot stands poised to play a crucial role in enhancing security measures and ensuring the safety of individuals and assets in diverse environments.

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