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IoT BASED SURVEILLANCE ROBOT

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I.ABSTRACT

The IoT-Based Surveillance Robot is developed to provide safe and efficient monitoring in hazardous environments such as war fields, industrial areas, and public places. The main objective of this project is to reduce human risk by replacing direct human involvement with a remotely operated robotic system. The robot is controlled through an Android smartphone using Internet of Things (IoT) technology, allowing the user to operate it from a safe distance. The proposed system uses an ESP32-CAM module to capture and transmit live video through a web browser. This enables real-time surveillance of the surroundings and helps the user monitor the movement of the robot continuously. To improve navigation and safety, an ultrasonic sensor is used to detect obstacles in front of the robot. Whenever an obstacle is detected, the robot stops automatically to prevent collisions. A metal detector sensor is also integrated into the robot to identify metallic objects such as hidden bombs, weapons, or explosive materials. When a metallic object is detected, the system immediately activates a buzzer alert to warn the user. The entire system is controlled by an Arduino UNO microcontroller, which coordinates all sensors, motors, and communication modules. Thus, the project provides a low-cost, reliable, and efficient solution for surveillance and safety applications.

Keywords: IoT, Surveillance Robot, ESP32-CAM, Arduino UNO, Ultrasonic Sensor, Metal Detector Sensor, Obstacle Detection, Live Video Streaming, Remote Monitoring, Hazardous Environment.

II. INTRODUCTION

The IoT-Based Surveillance Robot is designed to reduce human casualties and improve safety in hazardous environments such as war fields, disaster zones, industrial areas, and public places. In many dangerous situations, direct human monitoring is difficult and may lead to serious injuries or loss of life. Therefore, there is a need for a robotic system that can perform surveillance tasks remotely without putting human lives at risk. The proposed project aims to provide a low-cost and efficient solution for such applications. The robot is controlled remotely using an Android smartphone through Internet of Things (IoT) technology. A web-based interface is used to control the movement of the robot from a safe distance. The system is equipped with an ESP32-CAM module, which captures and transmits live video through the internet. The video can be viewed in a web browser, allowing the user to monitor the surroundings of the robot in real time. To improve safety and performance, the robot includes an ultrasonic sensor for obstacle detection. Whenever an object is detected in the path of the robot, the sensor sends a signal to the controller, and the robot stops automatically to avoid collision. A metal detector sensor is also integrated into the system to detect metallic objects such as hidden bombs, weapons, or explosive materials. When a metallic object is identified, the system activates a buzzer alert to notify the user. The entire system is controlled by an Arduino UNO microcontroller, which coordinates the sensors, motors, camera, and communication modules. Thus, the project combines IoT, embedded systems, and robotics to create an effective surveillance solution.

III. LITERATURE SURVEY

Nookala Venu proposed a surveillance robot using an ESP32-CAM module and Arduino. The robot was controlled remotely through Wi-Fi and provided live video streaming to a mobile device. The main achievement of this work was real-time monitoring of hazardous areas. However, the system mainly focused on surveillance and did not include metal

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detection or automatic obstacle avoidance.
Anandravisekar G., Anto Clinton A., Mukesh Raj T., and Naveen L. developed an IoT-based surveillance robot that could be controlled through a smartphone. Their work reduced the need for human presence in dangerous locations by providing wireless monitoring. The drawback of this system was that it did not include bomb detection, metal sensing, or obstacle detection.
Sanam Gourkhede and team proposed a robot that combined metal detection with wireless surveillance. The robot could detect metallic objects such as bombs or weapons and send alerts to the user. It also supported live monitoring through a camera module. However, the system did not include ultrasonic obstacle detection, so the robot could not avoid collisions automatically.
Himani Sharma and Navdeep Kanwal reviewed different IoT-based surveillance systems. Their study explained how cameras, sensors, and wireless communication improve monitoring and safety. They concluded that IoT-based surveillance provides real-time monitoring and alert systems. However, most of the reviewed systems were expensive and depended strongly on internet connectivity.

IV. PROPOSED WORK

The proposed work is to design and develop an IoT-Based Surveillance Robot capable of performing remote monitoring in hazardous and restricted areas. The robot is controlled through an Android smartphone using Internet of Things (IoT) technology. A web-based interface is used to move the robot in different directions such as forward, backward, left, and right.
An ESP32-CAM is integrated into the robot to capture and transmit live video through Wi-Fi. This allows the user to continuously observe the surroundings from a safe distance. To improve safety during movement, an Ultrasonic Sensor is used to detect obstacles in front of the robot. If an object is detected within a limited distance, the robot automatically stops to avoid collision. The robot also includes a Metal Detection Sensor to identify metallic objects such as bombs, weapons, or hidden metal parts. When metal is detected, the system immediately activates a Buzzer and an LED indication to alert the user. An Arduino Uno is used as the main controller to coordinate all the sensors and devices. Thus, the proposed system provides a low-cost, efficient, and reliable solution for surveillance and safety applications.

V. BLOCK DIAGRAM

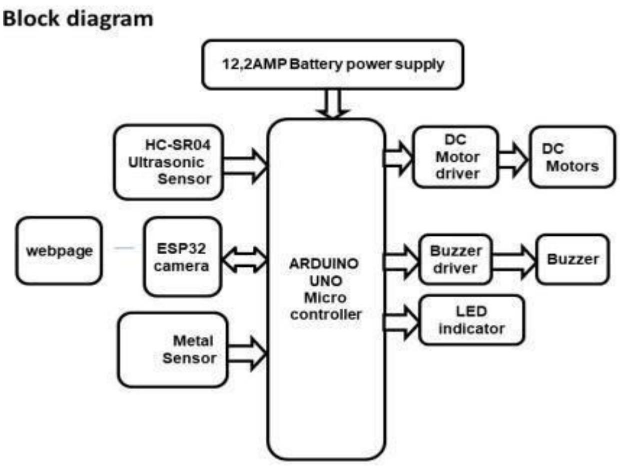

Fig. 1. Block Diagram

The block diagram of the IoT-Based Surveillance Robot represents the overall structure and interaction between different components. The main blocks include the power supply, controller, sensors, communication module, motor driver, and output devices.
The system is powered by a rechargeable battery, which supplies energy to all the components. The Arduino Uno acts as the central controller and coordinates the entire operation of the robot. It receives input signals from the sensors and sends control signals to the motor driver and other output devices. The ESP32-CAM forms the communication block, which captures live video and transmits it to the user’s mobile phone or browser through Wi-Fi. This enables real-time remote

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monitoring of the surroundings. The input section consists of the Ultrasonic Sensor and the Metal Detection Sensor. The ultrasonic sensor detects obstacles by measuring the distance between the robot and nearby objects, while the metal detector identifies metallic objects such as bombs or weapons. The output section includes the L293D Motor Driver and DC motors, which control the movement of the robot. Additionally, a Buzzer and LEDs are used to provide alerts and indications. Thus, all the blocks work together to perform remote surveillance, obstacle detection, and threat detection efficiently.

VI. CIRCUIT DIAGRAM

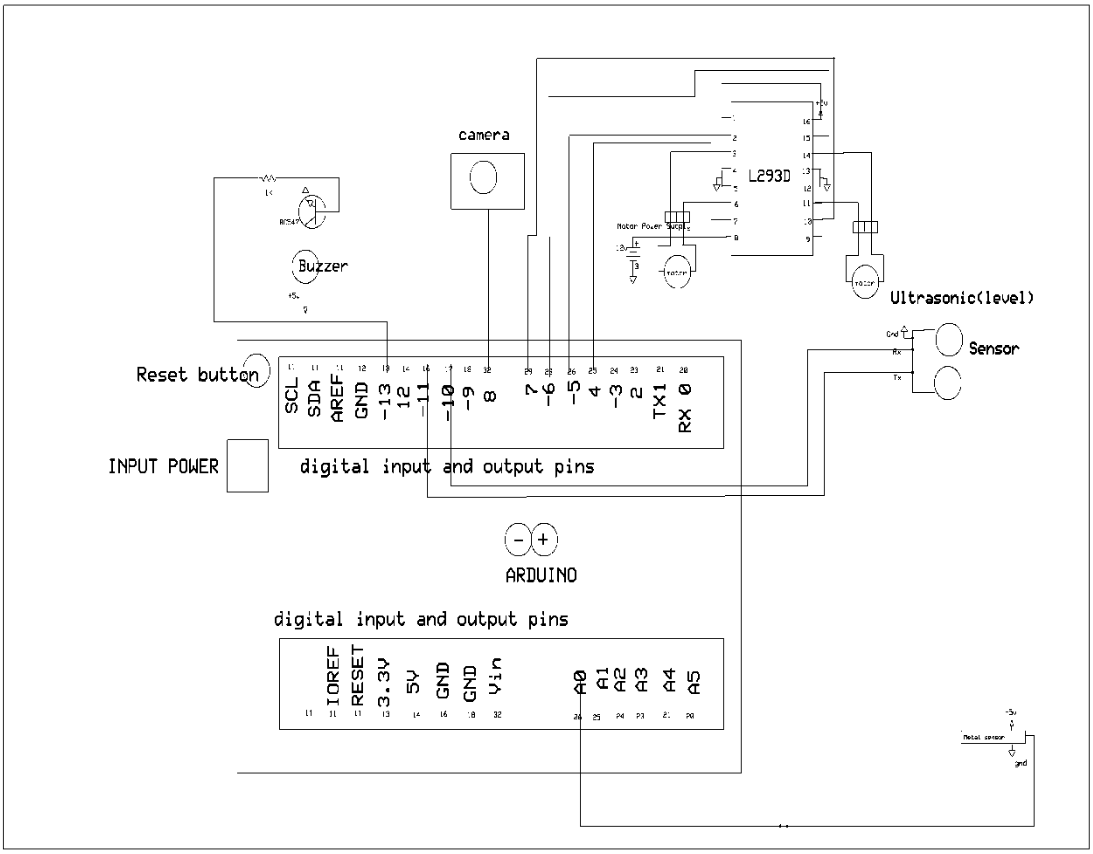

Fig . 2. Circuit diagram

VII. HARDWARE COMPONENTS

Arduino UNO: it is the main controlling unit of the surveillance robot. It is based on the ATmega328P microcontroller and is responsible for coordinating all the hardware components. The Arduino receives input signals from the ultrasonic sensor and metal detector sensor, processes them, and sends appropriate control signals to the motor driver, buzzer, and LEDs. It is programmed using Embedded C in the Arduino IDE and acts as the brain of the entire project.

Fig. 3. Arduino UNO

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ESP32-CAM: it is a compact camera module with built-in Wi-Fi and Bluetooth support. It is used in this project to capture live images and video from the surroundings. The ESP32-CAM transmits this video to the user's mobile phone or web browser through the internet, allowing real-time monitoring. Since it supports wireless communication, the user can observe dangerous areas remotely without being physically present.

Fig. 4. ESP32-CAM

Ultrasonic Sensor: it is used to detect obstacles in front of the robot. It works by sending ultrasonic sound waves and measuring the time taken for the waves to return after hitting an object. From this time, the distance between the robot and the obstacle is calculated. If the object is too close, the sensor sends a signal to the Arduino, which stops the robot automatically to prevent collision.

Fig. 5. Ultrasonic Sensor

Metal Detection Sensor: it is used to detect the presence of metallic objects such as bombs, weapons, or hidden metal pieces. The sensor creates a magnetic field and detects any change in it when a metal object is nearby. When metal is detected, the sensor sends a signal to the Arduino. The controller then activates the buzzer and LED to alert the user about the possible danger.

Fig. 6. Metal detection

L293D Motor Driver: it is an important component used to drive the DC motors of the robot. The Arduino alone cannot provide enough current to operate the motors directly. Therefore, the L293D motor driver is connected between the Arduino and the motors. It receives control signals from the Arduino and supplies the required current to the motors. It also controls the direction of rotation, enabling forward, backward, left, and right movement.

Fig. 7. L293 motor driver

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DC Motor: it is used to move the surveillance robot from one place to another. Usually, two DC motors are connected to the wheels of the robot. These motors rotate in different directions depending on the commands given by the Arduino through the motor driver. When both motors rotate forward, the robot moves ahead. Similarly, by changing motor directions, the robot can move backward or turn.

Fig. 8. DC Motor

Buzzer: it is used as an alerting device in the surveillance robot. Whenever the metal detector sensor identifies a metallic object, the Arduino activates the buzzer. The buzzer then produces a loud sound to warn the user about the detected object. This alert system is especially useful in bomb detection applications, where immediate attention is required to avoid accidents or danger.

Fig. 9. Buzzer

LED: it is used to provide visual indication of the robot’s operation and sensor status. The LED glows whenever the system detects an obstacle or a metallic object. Different LEDs may also be used to indicate power supply, motor operation, or successful detection. Since LEDs consume very little power, they are commonly used in embedded systems for displaying the current condition of the circuit.

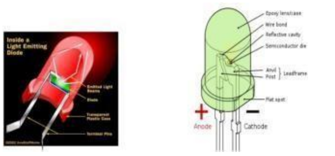


Fig. 10. LED

Battery: it is the power source of the surveillance robot. It provides electrical energy to all the components such as the Arduino, ESP32-CAM, sensors, motor driver, buzzer, and motors. A rechargeable battery is preferred because the robot may need to operate continuously for a long time. The battery makes the robot portable and allows it to move freely without requiring an external power connection.

Fig. 11. Battery

VIII. WORKING

The proposed IoT-based surveillance robot operates by integrating sensors, a microcontroller, and a wireless communication module to achieve real-time monitoring and control. The system is powered by a battery supply, which provides energy to all components.

Initially, the ultrasonic sensor continuously measures the distance between the robot and obstacles. The sensor sends this data to the Arduino UNO, which processes the signals and determines whether an obstacle is present. If an object is detected within a predefined range, the controller takes necessary action such as stopping or changing the direction of the robot.

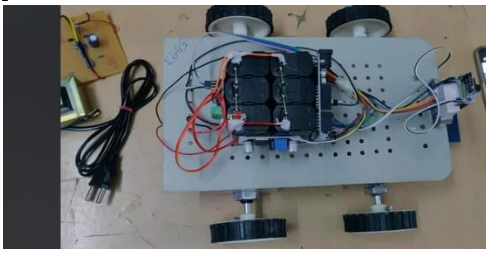
The Arduino UNO acts as the central processing unit of the system. It receives commands from the user through the WiFi module (ESP8266). These commands are transmitted via a mobile application, allowing the user to control the movement of the robot remotely. Based on the received commands, the Arduino sends control signals to the motor driver (L293D). The motor driver then drives the DC motors, enabling forward, backward, left, and right movements of the robot. Additionally, the system can be extended with a camera module for real-time video streaming, enhancing surveillance capabilities. Thus, the robot ensures efficient monitoring and obstacle avoidance through coordinated interaction between hardware components and wireless communication.

IX. IMPLEMENTATION

The implementation of the proposed IoT-based surveillance robot was carried out by integrating both hardware and software components. The hardware setup includes Arduino UNO as the main controller, ultrasonic sensor for obstacle detection, L293D motor driver for motor control, ESP8266 Wi-Fi module for communication, and DC motors for movement. All components were assembled on a robot chassis and powered using a rechargeable battery. The connections were established according to the designed circuit diagram. The ultrasonic sensor was interfaced with the Arduino to continuously monitor the distance, while the motor driver was connected to control the direction and speed of the motors. The ESP8266 module was configured to enable wireless communication between the robot and a mobile device. On the software side, the Arduino was programmed using Arduino IDE with embedded C code to control the overall operation of the system. The program was designed to read sensor data, process user commands received via Wi-Fi, and generate appropriate control signals for the motors. A mobile application was used to send control commands such as forward, backward, left, and right movements. The system was tested under different conditions to ensure proper communication, obstacle detection, and smooth operation of the robot.

X. RESULT

The proposed IoT-based surveillance robot was successfully implemented and tested under various conditions. The robot responded accurately to user commands received through the Wi-Fi module, enabling smooth movement in forward, backward, left, and right directions. The ultrasonic sensor effectively detected obstacles within a range of approximately 15 cm, and the system responded by stopping or altering the robot’s path to avoid collisions. The communication between the mobile application and the robot was stable, with minimal delay observed during operation. The overall system demonstrated reliable performance in terms of movement control, obstacle detection, and wireless communication, making it suitable for surveillance applications.



XI. CONCLUSION

The proposed IoT-based surveillance robot was successfully designed and implemented to achieve real-time monitoring and control using wireless communication. The system integrates essential hardware components such as Arduino UNO, ultrasonic sensor, motor driver, and Wi-Fi module to perform coordinated operations effectively. The developed robot demonstrates the ability to navigate in different directions based on user commands while simultaneously detecting obstacles in its path.

The implementation results indicate that the system performs reliably under various operating conditions. The ultrasonic sensor accurately detects obstacles within a specified range, enabling the robot to take preventive actions such as stopping or changing direction. The integration of the Wi-Fi module allows seamless communication between the robot and the user, ensuring real-time control with minimal delay. This makes the system suitable for applications where remote monitoring and quick response are required. Furthermore, the project highlights the importance of combining embedded

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systems with IoT technology to develop intelligent and autonomous systems. The use of cost-effective components makes the system affordable and easy to implement, which is beneficial for academic and practical applications. The modular design also allows future enhancements without major modifications to the existing system. In future work, the system can be enhanced by integrating a camera module for live video streaming, GPS for location tracking, and advanced sensors for improved environmental awareness. Artificial intelligence techniques can also be incorporated to enable autonomous decision-making and path planning. These improvements would significantly increase the efficiency and applicability of the surveillance robot in real-world scenarios such as security monitoring, military operations, and disaster management.

In conclusion, the developed IoT-based surveillance robot provides an efficient, flexible, and scalable solution for remote monitoring and control, demonstrating the potential of IoT in modern robotic systems.

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