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Advanced Surveillance Robot For Comprehensive Security Coverage

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Abstract: This paper presents the design and development of an "Advanced Surveillance Robot for Comprehensive Security Coverage," which integrates real-time monitoring, environmental sensing, and remote operational capabilities. The robotic system is powered by an Arduino Uno microcontroller, interfaced with an ESP32 CAM module for live video streaming and image capture. Mobility is achieved through a robust design utilizing TT gears and an L298H motor driver, enabling smooth navigation and obstacle handling. The system features two gas sensors, MQ135 and MQ7, to detect toxic gases and assess air quality, providing an additional layer of safety. A GPS module is integrated to facilitate location tracking, enabling precise positioning of the robot in dynamic environments. Servo motors are used to control the camera's angle, ensuring flexible and wide-area surveillance coverage. This work highlights the application of IoT and robotics to address modern security challenges, particularly in industrial safety, disaster management, and residential security. The robot's modular design ensures adaptability for various use cases, making it a scalable and versatile solution. Experimental results demonstrate the system's reliability in real-world scenarios, underlining its potential for comprehensive security applications.

Keywords- Advanced Surveillance Robot, Security Coverage, Arduino Uno, ESP32 CAM, Gas Sensors (MQ135, MQ7), GPS Integration

I. INTRODUCTION

Surveillance and security have become critical concerns in various domains, including residential, industrial, and public infrastructure. Traditional surveillance systems often rely on static cameras or human intervention, which can be limited in adaptability and scope. The integration of robotics and IoT (Internet of Things) technologies offers a promising solution to address these limitations by enabling intelligent, mobile, and real-time monitoring systems. This paper introduces the "Advanced Surveillance Robot for Comprehensive Security Coverage," a versatile robotic system designed to enhance security operations. The robot combines mobility, environmental sensing, and real-time data transmission, making it suitable for diverse applications such as disaster response, hazardous gas detection, and perimeter surveillance. At the core of the system is the Arduino Uno microcontroller, which orchestrates the robot's operations. The ESP32 CAM module facilitates live video streaming and image processing, while the integration of TT gears and an L298H motor driver ensures smooth navigation. To address environmental monitoring needs, the robot is equipped with two gas sensors, MQ135 and MQ7, capable of detecting toxic gases and monitoring air quality. Additionally, the GPS module enables precise tracking of the robot's location, ensuring operational reliability in dynamic and large-scale environments. The primary objective of this project is to develop a cost-effective, modular, and scalable robotic system capable of addressing modern

security challenges. This paper details the design, hardware integration, and experimental results of the surveillance robot, highlighting its potential applications in real-world scenarios.

II. LITERATURE SURVEY

The Advanced Surveillance Robot is a cutting-edge security system designed to enhance monitoring and threat detection capabilities. This project integrates Arduino Uno, ESP32 CAM, servo motors, L298N motor driver, TT gear motors, GPS module, and gas sensors (MQ-135 and MQ-7) to provide a robust surveillance solution. Additionally, an independent circuit with an Arduino module and an MQ-135 gas sensor has been incorporated to enhance gas detection capabilities. The surveillance robot is designed to patrol an area autonomously while capturing real-time video footage using the ESP32 CAM module. The GPS module helps track its location, ensuring efficient navigation and real-time monitoring. The gas sensors (MQ-135 and MQ-7) detect harmful gases, making the robot highly useful in industrial safety, hazardous environments, and security applications. With advancements in IoT and embedded systems, autonomous surveillance robots are becoming more effective in modern security applications. The integration of wireless connectivity and sensor-based automation reduces human intervention while improving efficiency. The additional independent circuit enhances the system's reliability by ensuring continuous gas monitoring even if the primary system fails. This research reviews existing surveillance and gas detection technologies, focusing on hardware implementation, real-time monitoring, and automation. The system aims to enhance security, reduce risks in hazardous environments, and provide an efficient, real-time surveillance solution adaptable to various applications such as industrial monitoring, defense, and public safety.

III. OBJECTIVE

1. To design an autonomous surveillance robot equipped with real-time video monitoring.
2. To integrate gas sensors (MQ-135 and MQ-7) for detecting harmful gases in the environment.
3. To implement GPS tracking for real-time location monitoring and navigation.
4. To enhance automation and wireless control for remote surveillance applications.
5. To develop an independent gas detection circuit using Arduino and MQ-135 to ensure continuous air quality monitoring
6. To minimize human intervention in surveillance and hazardous gas detection.

IV. METHODOLOGY

1. The system consists of an ESP32 CAM module, GPS module, servo motors, L298N motor driver, TT gear motors, Arduino Uno, MQ-135 and MQ-7 gas sensors, and an independent Arduino-based gas monitoring circuit.
2. The ESP32 CAM module captures and transmits live video feed for real-time surveillance.
3. The GPS module helps in tracking the robot's movement and positioning.
4. The gas sensors (MQ-135 and MQ-7) continuously monitor air quality and detect harmful gases.
5. An independent Arduino module with an MQ-135 sensor ensures uninterrupted gas detection even if the primary system fails.
6. The system is automated using a microcontroller, reducing the need for manual control.
7. The surveillance robot is designed to operate in hazardous environments, providing enhanced security and safety monitoring.
8. Wireless communication and IoT-based functionalities enable remote access and monitoring of the system.

V. COMPONENTS

1. ESP32-CAM Module

- A microcontroller with an integrated camera module
- Supports Wi-Fi and Bluetooth for wireless communication
- Used for real-time video streaming and remote monitoring

2. Arduino Uno

- ATmega328P-based microcontroller board
- Controls various sensors and modules
- Processes data from the MQ-135 gas sensor and other components

3. MQ-135 Gas Sensor

- Detects harmful gases such as ammonia, benzene, and smoke
- Provides analog output that can be processed by the Arduino
- Used for environmental monitoring and safety applications

4. L298N Motor Driver Module

- Dual H-Bridge motor driver
- Controls the speed and direction of DC motors
- Compatible with TT gear motors used for robot movement

5. TT Gear Motors (2 or 4)

- Small DC motors with built-in gear reduction
- Provide the necessary torque for moving the robot
- Operate efficiently with L298N motor driver

6. Servo Motors (SG90)

- Small and lightweight servo motor with plastic gears
- Operates on 4.8V to 6V DC
- Provides a rotation range of 0° to 180°
- Torque: 1.8 kg/cm (4.8V) and 2.5 kg/cm (6V)
- Used for controlling the camera's tilt and pan in the surveillance system

7. GPS Module (NEO-6M or similar)

- Provides real-time location tracking
- Uses satellite signals for navigation
- Helps in tracking the robot's position remotely

8. Lithium Polymer (LiPo) Battery

- Provides power to all components
- Lightweight and rechargeable
- Ensures long operational duration for the robot

9. Battery Management Circuit

- Regulates charging and discharging of the LiPo battery
- Prevents overcharging and overheating
- Enhances battery life and system efficiency

10. Chassis (Acrylic/Metal/Plastic)

- Framework for mounting all components
- Provides structural integrity to the robot
- Designed for easy movement and component protection

11. Wheels

- Attached to TT gear motors for mobility
- Made of rubber or plastic for better traction
- Enables smooth movement of the robot on different surfaces

12. Jumper Wires

- Used for electrical connections between components
- Available in male-to-male, male-to-female, and female-to-female types
- Ensures reliable communication between sensors and controllers

13. Buck-Boost Converter Module

- A **Buck-Boost Converter** is a DC-DC converter that can **step up (boost)** or **step down (buck)** voltage as required.
- Unlike a simple buck converter (which only steps down voltage), this module can regulate power efficiently by adjusting voltage levels dynamically.
- Ensures stable power supply to components like **ESP32, Arduino, and sensors**, even when battery voltage fluctuates.
- Helps maintain **consistent operation** of the surveillance robot by providing the required voltage for different modules.
- **Input Voltage Range:** 3V - 35V
- **Output Voltage Range:** 5V - 45V (adjustable)
- **Efficiency:** Up to 90% depending on input and output voltage levels
- Used to **stabilize power supply** in battery-operated systems.

14. LED Indicators

- Provide visual feedback on system status
- Indicate power, Wi-Fi connection, and sensor activity
- Help in debugging and monitoring system performance

15. Resistors, Capacitors, and Other Passive Components

- Used for circuit stability and signal conditioning
- Enhance sensor accuracy and system reliability

VI. BLOCK DIAGRAM

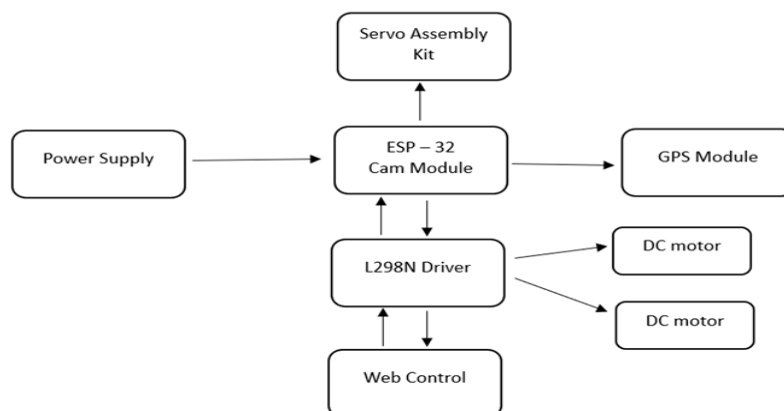


Figure.1

1. ESP-CAM32 Module: The ESP-CAM32 module, which combines the camera module and the ESP32 microcontroller, is represented by the central block. The robot's brain, the ESP32, is responsible for both

wireless communication and function control. The camera module records pictures and videos that can be edited, sent, and used for monitoring.

2. **Motor Control:** The motor control circuit, which consists of motor connections and motor drivers, is represented by this block. When necessary, the robot can move forward, backward, turn, or stop thanks to the ESP32's control over the motors' speed and direction.

3. **Power Supply:** The surveillance robot's energy source is represented by the power supply block. It usually consists of LiPo cells or batteries, which supply the voltage and current required to run the motors, ESP-CAM32, and other parts.

4. **Wireless Communication:** Bluetooth and Wi-Fi built into the ESP32 are crucial for wireless communication. The communication channel between the robot and other devices—like computers, smartphones, or distant servers—is represented by this block. It makes data transmission and remote control possible.

5. **Servo assembly kit:** servo assembly kit allows for precise control of the camera's orientation, facilitating panning and tilting. Here's a detailed overview of the typical servo assembly kit used in such. **Servo Motors (SG90 or MG995):** Small, precise motors used to control the camera's angle. Capable of rotating to a specified position between 0° to 180°. Usually comes with various plastic horns (arms) to connect to the camera or other parts.

6. **The L298N Motor Driver** is a popular and robust module used to control DC motors and stepper motors in robotics projects. In your surveillance robot, the L298N driver is crucial for managing the movement of the robot by controlling the TT gear motors.

7. **Arduino Module:** The Arduino module acts as an additional processing unit in the surveillance robot. It is responsible for handling sensor data, executing programmed instructions, and ensuring smooth communication with other components. The Arduino controls the independent gas detection circuit, making the system more efficient and reliable.

8. **MQ-135 Gas Sensor:** The MQ-135 gas sensor is a critical component for detecting harmful gases in the environment. It continuously monitors air quality and provides real-time data, which can be processed by the Arduino and ESP32. The sensor is designed to detect a wide range of gases, making it ideal for security and environmental applications.

VII. SOFTWARE DESIGN

7.1 Circuit diagram

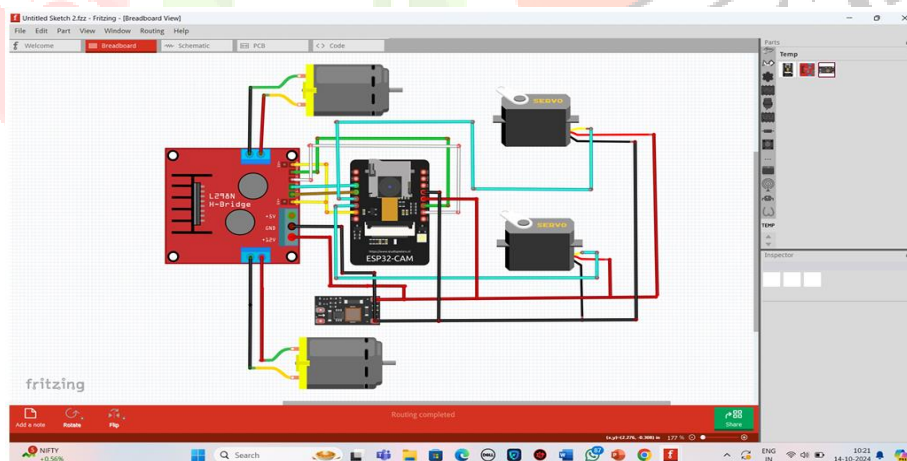


Figure.2

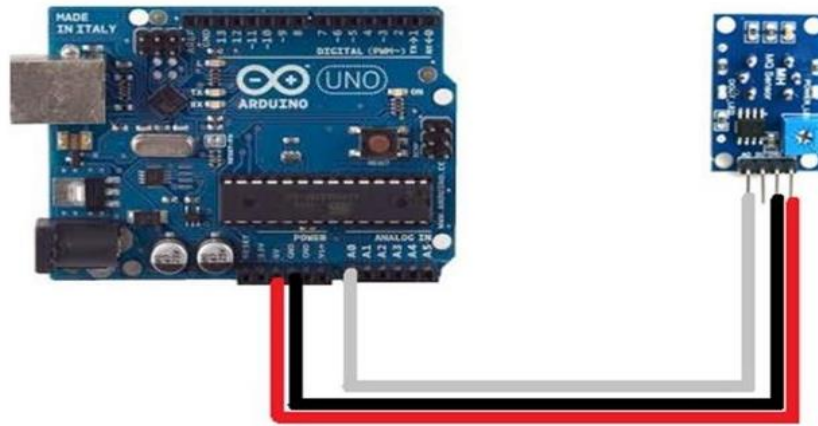


Figure.3

VIII. APPLICATION

1. Used for security surveillance in residential, commercial, and industrial areas.
2. Monitoring air quality in industries, factories, and enclosed environments.
3. Home automation and safety monitoring systems.
4. Used in warehouses and storage facilities for detecting hazardous gases.
5. Border surveillance and military applications.
6. Environmental pollution monitoring in urban and rural areas.

IX. Can be modified for indoor air quality assessment in hospitals and offices.

X. Future scope

1. The surveillance robot can be integrated with AI-based image processing for intelligent threat detection.
2. Additional sensors can be incorporated to monitor temperature, humidity, and air quality in real time.
3. The system can be enhanced with GPS tracking for remote location monitoring.
4. Mobile application integration can allow users to control and monitor the robot remotely.
5. Night vision capabilities can be added for enhanced surveillance in low-light conditions.
6. Solar power integration can improve efficiency and extend operational hours.

XI. CONCLUSION

This surveillance robot plays a crucial role in enhancing security and environmental monitoring through automation. The integration of the MQ-135 gas sensor allows real-time detection of harmful gases, making it highly effective for various applications. The ESP32-CAM module provides wireless monitoring capabilities, ensuring continuous surveillance without human intervention. With further research and innovation, this project can be expanded to incorporate advanced AI-based threat detection and automated responses, making it a valuable tool for security and environmental safety.

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