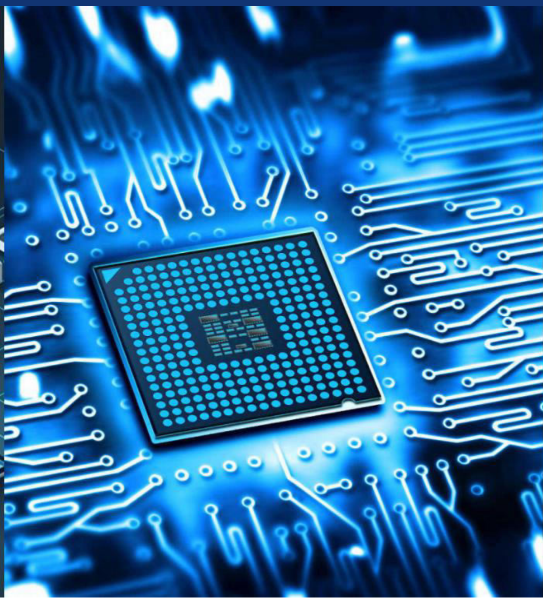
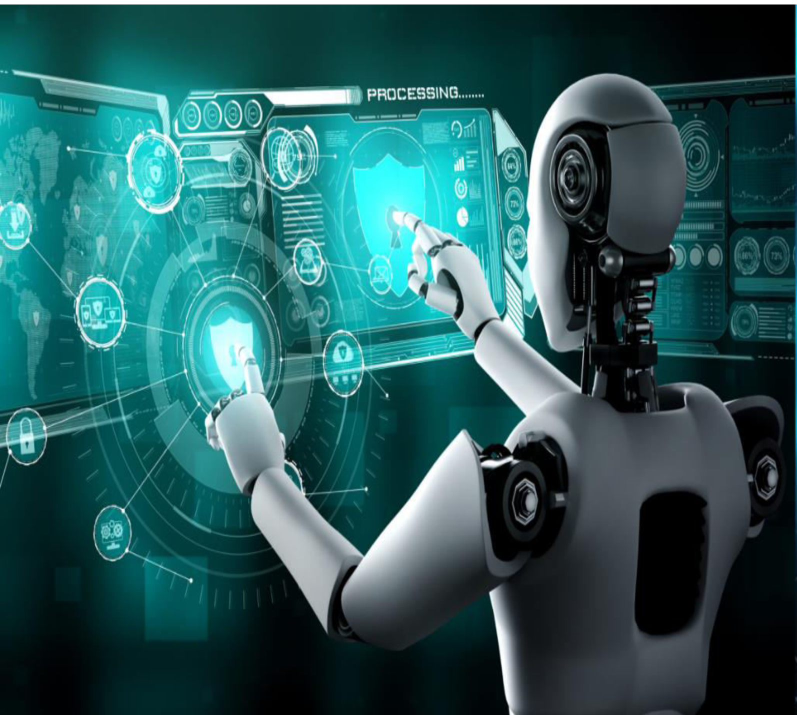
IJIRCCE

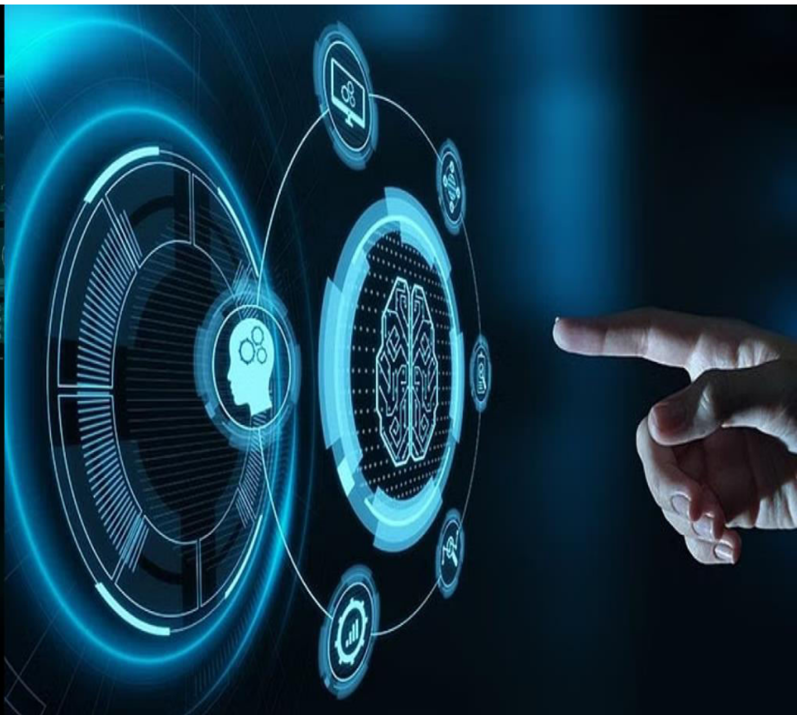
ISSN(O): 2320-9801
ISSN(P): 2320-9798


International Journal of Innovative Research in Computer and Communication Engineering

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)





Impact Factor: 8.771

Volume 14, Issue 4, April 2026

www.ijircce.com   ijircce@gmail.com   +91-9940572462   +91 63819 07438

© 2026 IJIRCCE | Volume 14, Issue 4, April 2026 DOI: 10.15680/IJIRCCE.2026.1404119

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Multi-Sensor IoT Rover for Smart Surveillance and Environmental Analysis

Mrs M Tharangini, MTech, Ms V.Sai Varshita, Mr Bammidi Vivek, Mr Akkireddi Nivas, Mr.Siyyadri Ram Prasad

Assistant Professor, Department of Electronics and Communication Engineering, Gayatri Vidya Parishad College for Degree and PG Courses, Visakhapatnam, India

Department of Electronics and Communication Engineering, Gayatri Vidya Parishad College for Degree and PG Courses, Visakhapatnam, India

Department of Electronics and Communication Engineering, Gayatri Vidya Parishad College for Degree and PG Courses, Visakhapatnam, India

Department of Electronics and Communication Engineering, Gayatri Vidya Parishad College for Degree and PG Courses, Visakhapatnam, India

Department of Electronics and Communication Engineering, Gayatri Vidya Parishad College for Degree and PG Courses, Visakhapatnam, India

ABSTRACT: IoT-enabled rover for real-time environmental monitoring and hazard detection. The system is equipped with multiple sensors, including gas, temperature, humidity, and ultrasonic sensors, to collect and analyze environmental data. The ESP32-CAM module with a pan-tilt mechanism provides 360 degree surveillance. A web-based interface enables remote control and real-time monitoring. The system is suitable for hazardous environments such as mining industries and gas plants. Overall, it provides a cost-effective and intelligent solution for environmental monitoring and safety applications.

KEYWORDS: IoT, ESP32-CAM, Gas Detection, Risk Classification, Environmental Monitoring, Web Interface, Rover

I. INTRODUCTION

The Internet of Things (IoT) has significantly advanced embedded and robotic systems by enabling remote connectiv ity, real-time data acquisition, and control. These systems are widely used in applications such as safety monitoring, environ mental analysis, agriculture, and disaster management. Most IoT-based systems collect sensor data and transmit it using microcontrollers like the ESP32. However, they are primarily limited to monitoring and displaying data without making decisions. They provide information such as gas concentration, temperature, and humidity, but do not evaluate the level of risk. As a result, users must continuously monitor the system and manually interpret the data to identify potential hazards. This process can lead to delays, especially in critical situations. To overcome these limitations, this work proposes an IoT based rover capable of real-time environmental monitoring with automatic risk classification.

II. LITERATURE SURVEY

Several research works have explored IoT-based environmental monitoring systems. Studies such as those by Buelvas et al. (2023) focus on improving data quality in air quality monitoring systems. Other works emphasize the integration of machine learning and IoT for water quality monitoring and environmental analysis.

Recent developments also include IoT-enabled surveillance systems using ESP32-CAM modules for real-time monitoring and control. These systems provide live video streaming and remote accessibility, improving situational

© 2026 IJIRCCE | Volume 14, Issue 4, April 2026 DOI: 10.15680/IJIRCCE.2026.1404119

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

awareness. Additionally, research on ultrasonic sensor-based obstacle detection has contributed to advancements in autonomous robotic navigation.

Despite these developments, most existing systems lack intelligent data interpretation and automated response mechanisms. They primarily focus on data collection and visualization without integrating decision-making capabilities. This highlights the need for systems that can not only monitor but also analyze and respond to environmental conditions effectively.

III. PROPOSED SYSTEM

The proposed system is an IoT-based intelligent rover using ESP32-CAM. It integrates multiple sensors such as gas sensors, DHT11/22, and ultrasonic sensors. The system processes sensor data and classifies environmental conditions into safe, moderate, and high risk. Automatic actions like buzzer alerts and rover stopping are triggered during hazards. A web interface allows remote monitoring and control.

IV. METHODOLOGY

This proposed system consists of a smart IoT rover with multiple modules that work together to perform specific tasks. The overall functionality of the system can be explained through its architecture, where each block is responsible for sensing, processing, communication, control, and power management.

A. User Device

The user device acts as the primary interface to interact with the rover system. The user accesses the embedded web interface through a browser running on a mobile phone or laptop. Through this interface, users can view real-time sensor data such as gas levels, temperature, humidity, and distance. Additionally, users can watch live video streaming from the ESP32-CAM and send commands to control the rover.

B. Wi-Fi Router

The Wi-Fi router acts as the communication layer between the user device and the rover. It enables wireless data trans mission over a local network using the HTTP protocol. User commands and sensor data are exchanged continuously to maintain real- time communication. The router ensures stable connectivity and supports multiple devices for remote moni toring.

C. ESP32 Controller

The ESP32 controller serves as the main processing unit and web server of the system. Its functions include: • Acquiring data from connected sensors • Processing data using the risk classification algorithm • Handling user commands from the web interface • Controlling rover movement It integrates sensing, processing, and communication into a single unit.

D. Web Interface

The embedded web interface is hosted on the ESP32 and can be accessed through a web browser. It displays: • Real time sensor readings (gas, temperature, humidity, distance) • Rover control buttons (forward, backward, left, right, stop) • System status and alerts This interface combines monitoring and control in a single platform, making the system easy to use without additional software.

E. Sensors

The DHT11/22 sensor measures the temperature and hu midity of the surrounding environment. This data helps in an alyzing environmental conditions and detecting abnormalities. MQ-3 Gas Sensor The MQ-3 sensor detects the presence of harmful gases in the environment. It provides analog output, which is converted into digital form for processing by the controller. The system compares the values with predefined thresholds to determine the safety level. Ultrasonic Sensor (HC-SR04) The ultrasonic sensor is used for obstacle detec tion. It measures the distance between the rover and nearby objects by transmitting ultrasonic waves and calculating the time taken for the echo to return

© 2026 IJIRCCE | Volume 14, Issue 4, April 2026 DOI: 10.15680/IJIRCCE.2026.1404119

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

F. ESP32-CAM

The ESP32-CAM captures live video and streams it to the user's browser over Wi-Fi. This provides visual feedback of the environment and enhances situational awareness during remote operation

G. Motor Driver and Motors

The motor driver acts as an interface between the ESP32 and the DC motors. It amplifies control signals from the controller to drive the motors, enabling control over direction and speed. The rover uses multiple DC motors arranged in a multi-wheel configuration. These motors enable movement in different directions such as forward, backward, left, and right.

H. Power Supply

The system is powered by a battery. A buck converter is used to regulate the voltage and provide a stable power supply to the ESP32, sensors, and motor driver.

V. WEB INTERFACE DESIGN

The web interface is implemented as a browser-based dashboard embedded directly in the ESP32 microcontroller, eliminating the need for any additional software applications. Users can access the dashboard through a web browser by entering the IP address assigned to the ESP32 on a mobile phone or laptop.

A. Live Camera

This section displays the live video stream captured by the ESP32-CAM. The camera feed is continuously updated to provide real-time visual information about the rover's surroundings. This enhances navigation accuracy and improves situational awareness during remote operation.

B. Control Panel

This section includes directional control buttons such as forward, backward, left, right, and stop. Each button sends an HTTP request to the ESP32, which processes the request and controls the motor driver accordingly to move the rover.

C. Sensor Data

This section presents real-time data collected from sensors, including temperature, humidity, gas levels, and distance mea surements. The data is updated automatically without requiring page refresh, ensuring continuous monitoring.

D. Communication

Sensor data is processed in real time by the ESP32 and transmitted to the web interface. The system uses the HTTP protocol over Wi-Fi to enable communication between the user and the rover. It supports bidirectional data flow, where control commands are sent from the user to the rover, and sensor data along with system status is sent back to the interface. This ensures seamless and real-time interaction.

E. UI Design

The dashboard is designed with a dark (black) theme to improve visibility and reduce eye strain. Control buttons are highlighted in green, and sensor data is organized into structured panels. This enhances usability and provides a clean and intuitive user experience.All functionalities, including live video streaming, rover control, and sensor monitoring, are integrated into a single dashboard. This unified interface improves convenience and eliminates the need for multiple applications.

VI. RESULTS

The proposed system was tested under various environ mental conditions to evaluate its performance. The rover successfully collected and transmitted sensor data in real time without noticeable communication delay. The risk classifica tion mechanism accurately identified environmental conditions based on sensor inputs. The web-based interface maintained a stable connection and enabled precise control of the rover's REFERENCES movements. Additionally, the video streaming feature provided continuous and reliable visual feedback from the ESP32-CAM, improving monitoring and navigation.

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

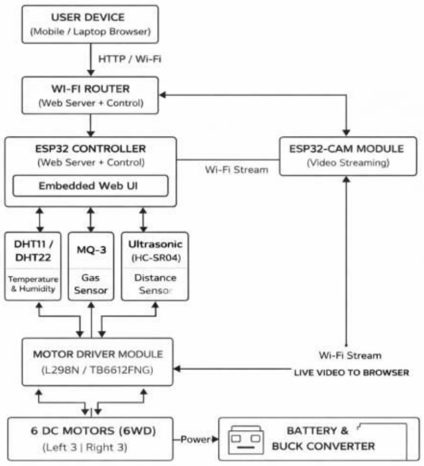


Fig 1: Block diagram

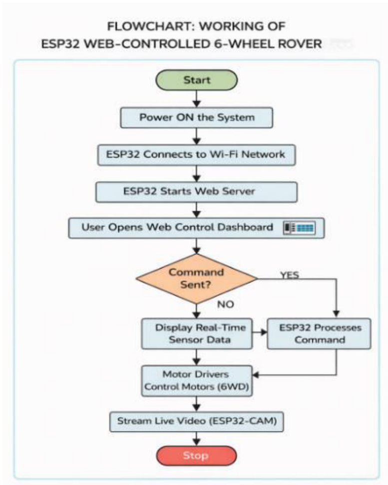


Fig2 : the flow chart of the IoT – based six wheel rover with ESP32 CAM interface

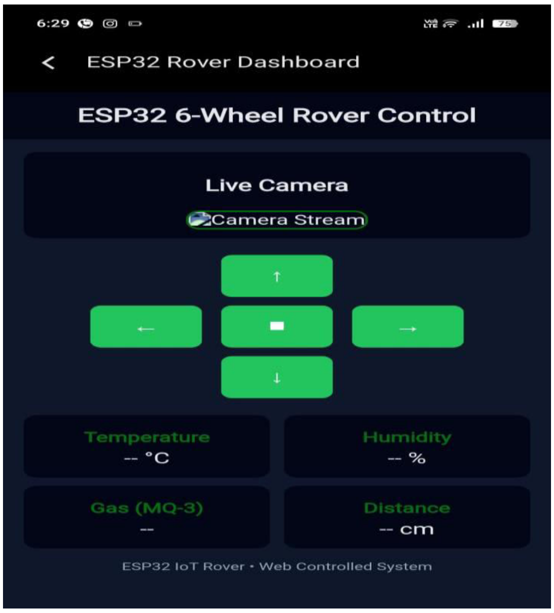


Fig 3: The real – time web page used to control the IoT – based rover and monitor the sensor data

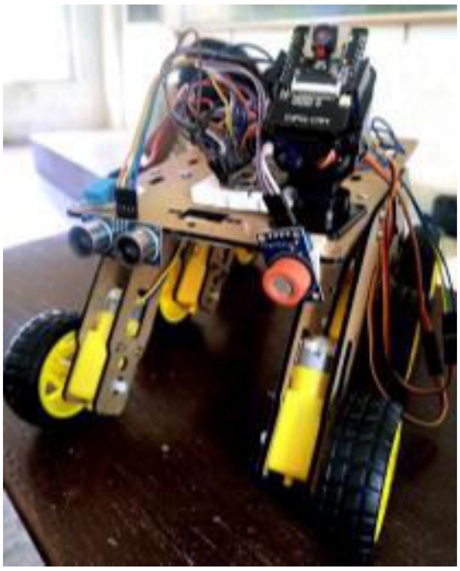


Fig 4: The Design of an IoT- Based Intelligent with Real-Time Rover six wheel Environmental Risk Classification and Web- Based Control

V. CONCLUSION

The proposed system demonstrates an intelligent IoT-based rover capable of real-time monitoring, navigation, and risk assessment. By integrating sensors, the ESP32 module, and a web-based interface, the system effectively collects, processes, and utilizes environmental data for decision-making. The implementation of a risk classification mechanism enables the system to respond to hazardous conditions promptly, reducing the need for continuous human monitoring. In addition, the modular and scalable design allows easy integration of ad vanced features and technologies in the future. Overall, the proposed IoT-based rover provides a cost-effective, efficient, and reliable solution for environmental monitoring and safety applications.

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

VI. FUTURE SCOPE

The proposed system can be further enhanced by integrating advanced technologies such as machine learning to enable predictive monitoring and intelligent decision-making. Cloud computing can be incorporated to support large-scale data storage and provide remote access for monitoring and analysis. The implementation of autonomous navigation can reduce manual control and improve operational efficiency. Addition ally, expanding the sensor network and enhancing image processing capabilities can increase the accuracy and effective ness of the system. Future work may also include conducting field tests in real-world industrial environments, evaluating and optimizing risk classification algorithms, developing efficient path-planning and obstacle-avoidance techniques, implement ing cloud-based dashboards for remote monitoring, integrating additional sensors such as CO and vibration sensors, and improving the web interface through user experience analysis.

REFERENCES

[1] Buelvas, J., Mu´nera, D., V., D. P., Aguirre, J. Gaviria, N. (2023). Data Quality in IoT-Based Air Quality Monitoring Systems: a Systematic Mapping Study. Water 234. https://doi.org/10.1007/s11270-023-06127-9.

[2] Advances in machine learning and IoT for water quality monitoring: A comprehensive review. Environmental Monitoring and Assessment 195(1). https://doi.org/10.1007/s10661-022-10656-0 .

[3] Designing an Evaluation Framework for IoT Environmental Monitoring Systems. Procedia Computer Science 219, pp. 220-227. https://doi.org/10.1016/j.procs.2023.01.284 .

[4] Vimal, M., K S. Abishek, A. (2025). Design and Implementation of an IoT-Enabled Rover with ESP32 CAM for Object Detection, Environ- mental Monitoring, and Web-Based Control. Proceedings of the International Conference on Multi-Agent Systems for Collaborative Intelligence. https://doi.org/10.1109/icmsci62561.2025.10894020 .

[5] Zhang, H., Zhang, R. Sun, J. (2025). Developing real-time IoT-based public safety alert and emergency response systems. Scientific Reports 15. https://doi.org/10.1038/s41598-025-13465-7.

[6] MQ-3 Gas Sensor," Electro-Base. https://electrobase.info/sensor/mq3

[7] Ma, J. (2023). Obstacle Detection and Avoidance Using Ultrasonic Sensors in Autonomous Robots. Highlights in Science, Engineering, and Technology 71:68-78. https://doi.org/10.54097/hset.v71i.12378

[8] Gaikwad, J., Madake, J., Jilla, A., Pamu, S., Chavan, A., Barde, A., Khatave, D., Wagaj, S. (2023). Smart Surveillance Rover: Real-Time Monitoring with ESP32-CAM and Pan-Tilt Servo Motor Integration. International Journal for Research in Applied Science and Engineering Technology 11(1), pp.1-5. https://doi.org/10.22214/ijraset.2023.57362