A Review on IoT-Based Smart Gas Leakage Detection and Alert System Using Robotic Automation(BOT)

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Abstract - Gas leaks are a serious concern in residential and industrial settings, as they can lead to accidents and property damage. Traditional detection methods relying on human observation are often slow and unreliable. To address this, the proposed IoT-based robotic gas leakage detection system provides an automated, real-time monitoring solution. It integrates an MQ-3 gas sensor with a NodeMCU ESP8266 microcontroller and IoT connectivity to detect hazardous gas levels promptly. The robotic car continuously patrols the area, collects sensor data, and transmits it to cloud platforms and mobile applications for remote monitoring. If gas concentrations exceed the threshold, the system triggers a buzzer alarm and sends SMS alerts to authorized personnel. A web application also enables data tracking, ensuring efficient safety management. This integrated setup offers a reliable, cost-effective solution that reduces human involvement and enhances safety across residential, industrial, and commercial environments.

Keywords — Gas Leakage Detection, Robotic System, MQ-135 Sensor, ESP8266 (NodeMCU), Real-Time Monitoring, Wireless Communication, Safety Automation, Smart Surveillance.

I. INTRODUCTION - Gas leakage remains a major safety concern in both residential and industrial environments due to the extensive use of combustible and toxic gases such as LPG, methane, and carbon monoxide. Accidental leaks can quickly create hazardous conditions, leading to fire, explosions, or serious health risks. Past incidents, including large-scale industrial disasters and frequent domestic accidents, highlight the need for reliable and timely gas detection systems. Traditional methods, which rely on human observation or fixed sensors, are often limited in coverage and response time, making them insufficient for dynamic or large areas.

With the advancement of technologies such as the Internet of Things (IoT), embedded systems, and automation, smarter solutions have emerged to address these challenges. IoT-enabled systems allow continuous monitoring, real-time data transmission, and remote accessibility through mobile and web platforms. When combined with robotic mobility, these systems can actively scan different locations, improving detection efficiency.

This paper focuses on an IoT-based robotic gas leakage detection system that utilizes sensors, microcontrollers, and wireless communication to identify gas leaks and generate instant alerts. The integration of mobility and real-time monitoring provides a more flexible, efficient, and reliable approach compared to conventional detection methods, contributing to improved safety and risk prevention.

II. LITERATURE SURVEY -

Several research works have been carried out in the field of gas leakage detection using embedded systems and IoT technologies. Early systems mainly focused on fixed gas sensors integrated with microcontrollers such as Arduino to detect LPG leakage and trigger local alerts like buzzers or LEDs. While these systems were simple and cost-effective, they were limited in terms of coverage, as they could only monitor a specific location and lacked remote communication capabilities.

With the introduction of IoT, many researchers developed systems that could transmit real-time gas concentration data to cloud platforms and mobile applications. These solutions improved monitoring by enabling users to receive alerts through SMS, mobile apps, or web dashboards. However, most of these systems were highly dependent on stable internet or GSM connectivity, which could affect reliability in areas with poor network coverage. Additionally, several studies highlighted issues related to sensor calibration, false alarms, and limited detection of only specific gases such as LPG.

Fig- 1 : Acrylic Chassis

Recent advancements have explored the use of robotics in gas detection systems. Mobile robotic platforms equipped with gas sensors and wireless modules have been designed to patrol large areas and detect leaks dynamically. These systems offer better coverage and reduce human involvement in hazardous environments. However, many existing approaches still lack complete integration of features such as automated response mechanisms, multi-sensor fusion, and precise location tracking.

Overall, the literature indicates that while significant progress has been made in gas detection technologies, there is still a need for a more comprehensive solution that combines mobility, real-time monitoring, reliable communication, and efficient alert systems. The proposed IoT-based robotic gas leakage detection system aims to address these limitations by providing an integrated and practical approach for improved safety.

I. METHODOLOGY – The proposed system is designed to detect and alert in case of gas leakage using an IoT-enabled robotic car. The methodology involves both hardware and software integration to achieve autonomous monitoring, detection, and alert generation. The system uses various sensors, controllers, and communication modules to ensure safety and reliability.

- **System design**

1. Acrylic Chassis :

Fig- 2 : MQ-135 Gas Sensor (Analog & Digital Output)

The acrylic chassis acts as the base platform on which all electronic and mechanical components are mounted. It provides structural stability while keeping the system lightweight and compact.

2. MQ-135 Gas Sensor :

Fig- 6 : ESP8266 (NodeMCU Module)

Fig- 5 : BMS Controller

The MQ-135 sensor is used to detect harmful gases such as ammonia, benzene, smoke, and CO_2. It provides both analog and digital outputs for flexible interfacing.

3. L298N Motor Driver :

The L298N motor driver module is used to control the direction and speed of DC motors in the robotic system. It acts as an interface between the microcontroller and motors. It receives control signals from the ESP8266 and drives the motors accordingly. By controlling voltage polarity, it enables forward, backward, left, and right movement of the robot.

4. Lithium-Ion Battery :

The lithium-ion battery serves as the primary power source for the system. It is lightweight, rechargeable, and suitable for portable robotic applications.

Fig- 4 : Lithium-Ion Battery

5. BMS Controller (Battery Management

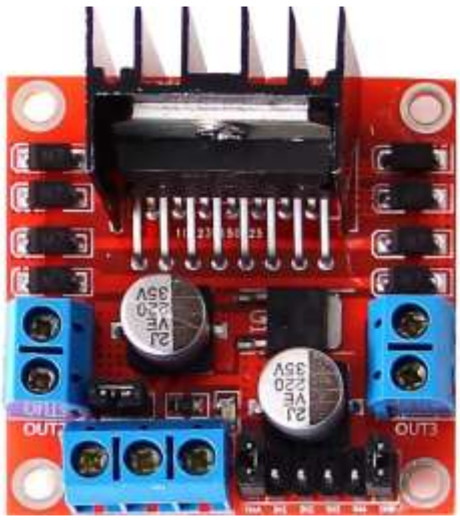

Fig- 3 : L298N Motor Driver

System)

The BMS module is used to manage and protect the lithium-ion battery. It ensures safe charging and discharging of the battery. It prevents overcharging, over-discharging, and short circuits by regulating voltage and current. This enhances battery life and ensures safe operation of the entire system.

6. ESP8266 (NodeMCU Module)

The ESP8266 is a Wi-Fi-enabled microcontroller that acts as the brain of the system. It processes sensor data and handles communication. It reads data from the MQ-135 sensor, analyzes gas levels, and controls the motor driver and alert system. It also sends real-time data to cloud platforms and mobile/web applications via Wi-Fi.

7. DC Motors :

DC motors are used to provide movement to the robotic car. They enable the system to cover different areas for gas detection. The motors are controlled by the L298N driver based on signals from the ESP8266. They allow the robot to move in multiple directions, enabling area scanning and dynamic gas monitoring.

The proposed system operates through continuous sensing and real-time processing to detect gas leakage efficiently. The MQ-135 sensor monitors gas levels in the environment and transmits the data to the ESP8266 microcontroller for analysis. The controller compares the readings with set threshold values and identifies any abnormal gas concentration. When a leak is detected, the system activates alerts such as a buzzer and sends notifications through IoT-based platforms. At the same time, the motor driver enables the robot to move and scan different areas for wider coverage. The lithium-ion battery, along with the BMS module, maintains a stable power supply for smooth operation. This approach ensures reliable gas detection and timely alerts with minimal human involvement.

IV. IMPLEMENTATION – The implementation of the proposed system involves integrating hardware and software components to achieve real-time gas detection and monitoring. The MQ-135 gas sensor is interfaced with the ESP8266 microcontroller to continuously collect gas concentration data. The microcontroller processes this data and compares it with predefined threshold values to identify potential gas leakage. Based on the analysis, the system activates alert mechanisms such as a buzzer and sends notifications through IoT platforms and mobile applications.

The robotic movement is controlled using the L298N motor driver, which receives signals from the ESP8266 to navigate the robot across different areas. This mobility allows the system to monitor a wider region compared to fixed detectors. Power is supplied through a lithium-ion battery, while the BMS module ensures safe and stable operation. The software part is developed using Arduino IDE for programming and IoT platforms for real-time data visualization and remote access. Overall, the implementation ensures coordinated functioning of sensing, processing, communication, and movement for efficient gas

Fig- 7 : DC Motors

leakage detection.

V. Results and Discussion – The proposed IoT-enabled robotic gas leakage detection system was successfully implemented and tested in a controlled environment. The primary objective was to ensure that the robot could accurately detect hazardous gas concentrations, provide timely alerts, and transmit real-time data to remote users through multiple communication channels. The integration of IoT, GSM, and robotics achieved an effective, reliable, and low-cost solution for gas monitoring applications in both industrial and residential settings.

The robotic movement enabled the system to monitor a wider area compared to stationary detectors, improving overall coverage and detection capability. Real-time data transmission to mobile and web applications allowed users to continuously track gas levels and system status remotely. The response time of the system was observed to be quick, ensuring immediate alerts in case of leakage.

Overall, the system demonstrated stable performance, accurate detection within its sensing range, and reliable communication under normal network conditions. These results indicate that the proposed system is effective for real-time gas monitoring and can significantly enhance safety in both residential and industrial environment

VI. APPLICATIONS – The IoT-enabled robotic gas leakage detection system can be implemented across a wide range of real-world environments to enhance safety and minimize the risk of accidents caused by undetected gas leaks. Owing to its wireless communication, portability, and flexibility, the system is well-suited for both residential and industrial use.

A. Residential Areas - The system can efficiently detect LPG or methane leaks from household gas stoves, pipelines, and cylinders. It helps prevent fire hazards by activating alarms and sending immediate notifications via SMS or a mobile application, thereby ensuring the safety of residents, especially in densely populated apartment buildings.

B. Industrial Facilities - In manufacturing, chemical, and petroleum industries where gases are frequently used, the system offers continuous monitoring of pipelines, storage zones, and machinery. Its autonomous mobility allows it to navigate large industrial sites, reducing the need for manual inspections and lowering the risk of large-scale gas-related incidents.

C. Laboratories and Research Centers - This system proves highly beneficial in laboratories that handle toxic or flammable gases. By continuously monitoring gas concentration levels and promptly alerting personnel to potential leaks, it ensures a safer working environment and prevents hazardous exposure.

D.Hospitals and Healthcare Units - In healthcare facilities where gases such as oxygen and nitrous oxide are commonly used, the system enables quick detection of leaks. This helps reduce wastage and ensures the safety of both patients and medical staff, particularly in critical care environments.

E. Storage and Distribution Centers - Gas depots and distribution facilities can utilize the system to continuously monitor tanks and cylinders. The robot’s mobility allows for real-time inspection of storage areas and immediate alert generation when gas concentration levels approach hazardous limits.

F. Smart Cities and Public Infrastructure - With further advancement, these robotic systems can be integrated into smart city safety frameworks. They can monitor underground pipelines or public gas networks, ensuring early detection of leaks and minimizing potential environmental damage.

VII. LIMITATIONS – Despite demonstrating efficient gas detection and reliable performance, the proposed IoT-based robotic gas leakage detection system possesses certain limitations that must be acknowledged. One of the primary challenges is its dependency on network connectivity. The system relies on Wi-Fi and GSM communication to transmit alerts and real-time data. In areas with weak signals or poor internet coverage, notifications may be delayed or fail entirely. This limitation can affect the timely response of personnel, especially in remote industrial zones or enclosed environments where signal strength fluctuates. Enhancing the system with hybrid communication methods or offline data storage could help mitigate this issue.

The MQ-135 sensor, while efficient, is not capable of detecting all types of hazardous gases with high accuracy and may require regular calibration to avoid incorrect readings. Environmental factors such as temperature and humidity can also influence sensor performance. Additionally, the system currently focuses only on detection and alert generation and does not include an automatic gas shut-off mechanism for preventive action.

Furthermore, the reliance on IoT platforms introduces potential security concerns, as unauthorized access may affect system reliability. Regular maintenance and proper configuration are therefore necessary to ensure consistent performance.

VIII.CONCLUSIONS – The proposed IoT-based robotic gas leakage detection system offers an efficient and practical solution for real-time gas monitoring and safety. By integrating gas sensors, a microcontroller, and wireless communication, the system can detect leaks quickly and provide timely alerts to users. The addition of robotic mobility improves coverage compared to traditional fixed systems, making it suitable for various environments. Despite some limitations related to connectivity, power, and sensor accuracy, the system remains a cost-effective and reliable approach for enhancing safety and reducing risks associated with gas leakage.

IX.FUTURE SCOPE - The proposed IoT-enabled robotic gas leakage detection system has immense potential for future improvements and wider applications. One of the key areas of enhancement lies in the integration of **advanced sensor technologies**. Instead of relying solely on a single MQ-3 sensor, the system can be upgraded with a multi-sensor array capable of detecting a broader range of gases such as carbon monoxide, ammonia, or hydrogen sulfide. Incorporating temperature, humidity, and pressure sensors can also improve the accuracy and reliability of gas detection by providing additional environmental context. Furthermore, the use of **AI-based sensor calibration** techniques could help maintain consistent accuracy over time without frequent manual intervention.

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