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Real-Time Prediction of Toxic Gases in Underground Drainage

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Abstract:
Underground drainage systems are hazardous environments where the accumulation of toxic and combustible gases such as methane, carbon monoxide, and liquefied petroleum gas (LPG) poses serious risks to human life and infrastructure. Traditional inspection methods are inefficient and unsafe. This paper proposes an AI-assisted IoT-based toxic gas prediction and water level monitoring system. The system integrates MQ2 and MQ3 gas sensors and an ultrasonic sensor with an ESP32 microcontroller for real-time data acquisition. A lightweight prediction model analyzes trends in gas concentration to provide early warnings before reaching critical thresholds. Alerts are generated via buzzer, GSM module, and GPS tracking. The proposed system improves safety, reduces response time, and supports smart city infrastructure.
Keywords — **Gas Detection, IoT, ESP32, GSM, GPS, Smart Cities, Prediction**

I. INTRODUCTION

Gas leakage is a major safety concern in both domestic and industrial environments, as the uncontrolled release of combustible or toxic gases can lead to severe accidents such as fires, explosions, and serious health hazards. In households, leakage of cooking gas may result in life-threatening situations, while in industries and gas storage facilities, even a small leakage can cause large-scale damage to property and human life. Due to the increasing use of gas-powered systems in daily life and industrial operations, ensuring early detection and timely alerting of gas leakage has become critically important.

This project presents an **Real-Time Prediction of Toxic Gases in Underground Drainage** designed to provide real-time monitoring and early warning in case of gas leakage. The system uses gas sensors to continuously sense the concentration of combustible or harmful gases in the surrounding environment. The ESP32 microcontroller processes the sensor data and compares it with predefined safety threshold levels. When the detected gas concentration exceeds the safe limit, the system immediately triggers an alert by activating a buzzer and notifying the user, thereby enabling quick preventive action.

II. RELATED WORKS

An easy way to comply with the conference paper Wireless and IoT-based gas leakage detection systems have been widely developed to improve safety in residential and industrial environments. MQ-series sensors are commonly used to detect combustible gases, and the sensed data is transmitted to cloud platforms for remote monitoring and storage . Several systems integrate microcontrollers such as NodeMCU or Arduino to process sensor data and trigger alerts through mobile applications or SMS notifications.

III. EXISTING SYSTEM

A. System Module

The existing system is an embedded gas leakage detection system designed to identify the presence of hazardous gases in the environment. It mainly focuses on providing safety in domestic and industrial areas by continuously monitoring gas concentration levels. The system detects leakage at an early stage and alerts user through basic alarm mechanisms to prevent accidents such as fire or explosions.

B. *Hardware Components Used*

The system consists of several hardware components that work together for gas detection. The primary component is the MQ-series gas sensor, which senses gases like LPG, methane, and carbon monoxide. A microcontroller such as Arduino Uno is used to process the sensor data. Other components include a buzzer for alert, LED indicators for status display, and sometimes an LCD screen to show gas concentration levels. These components are simple, cost-effective, and widely used in embedded systems.

C. *Working Principle*

The working principle of the system is based on gas sensing and signal processing. The MQ sensor detects the presence of gas and converts it into an electrical signal (analog voltage). This signal is sent to the microcontroller, which continuously reads and analyzes the data. The microcontroller compares the sensed value with a predefined threshold level to determine whether there is a gas leak.

D. *Gas Detection Mechanism*

The gas detection mechanism relies on the sensitivity of the MQ sensor to different gases. When gas concentration increases, the resistance of the sensor changes, resulting in a variation in output voltage. This voltage is interpreted by the microcontroller. If the detected gas concentration exceeds the set threshold value, it indicates a leakage condition. The threshold value is fixed and manually set based on safety limits.

IV. PROPOSED SYSTEM

A. *System Overview*

The system continuously monitors the environment for the presence of hazardous gases using **MQ-series gas sensors**. When the gas concentration exceeds a predefined threshold, the system immediately triggers alerts and sends notifications to users through wireless communication.

B. *System Architecture*

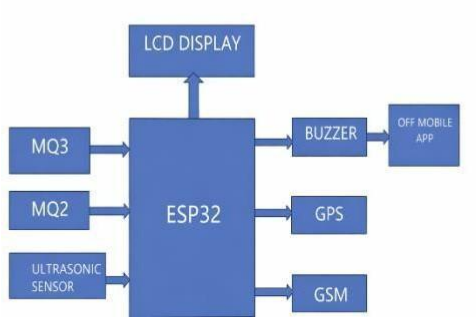

Fig 1. System architecture

Overall, the proposed **AI-Based Toxic Gas Prediction in Smart Cities** overcomes the limitations of existing solutions by offering continuous monitoring, early detection, and effective alert mechanisms in a cost-effective and user-friendly design. The system provides a practical and proactive approach to gas safety management and can be effectively applied in homes, industries, laboratories, gas storage facilities, and commercial buildings to enhance safety and protect human life and property.

V. SENSOR

A. *Gas Sensor (MQ2,MQ3 Gas Blocking Sensor)*

The MQ2 and MQ3 sensors act as the primary gas detection units. These sensors continuously monitor the surrounding air for the presence of combustible and harmful gases such as LPG, methane, alcohol vapors, and smoke. The sensors convert gas concentration levels into corresponding analog voltage signals, which reflect the intensity of gas presence in the environment.

B. Signal Conditioning & Sampling Block

This block ensures proper reading of sensor output by stabilizing and sampling the analog signals generated by the gas sensors. It helps reduce noise and ensures that the gas concentration values are accurately captured by the ESP32's ADC (Analog-to-Digital Converter).

C. ESP32 Microcontroller

The ESP32 serves as the central processing unit of the system. It reads sensor data, compares gas concentration values with predefined safety thresholds, executes decision-making logic, and controls all output devices. The ESP32 also manages timing, communication modules, and system states such as normal monitoring or emergency alert mode

D. Threshold Evaluation Block

This block compares real-time gas sensor values with predefined safe limits. If the detected gas concentration remains below the threshold, the system continues normal monitoring. When the concentration exceeds the threshold, the system identifies it as a gas leakage condition and immediately triggers alert mechanisms.

E. Buzzer (Local Alert System)

The buzzer provides an immediate audible alert when gas leakage is detected. It warns occupants in the vicinity about the hazardous condition, enabling quick evacuation or corrective action even without external communication.

F. Outcome of this Device

The complete system functions as a real-time, low-cost, and reliable gas leakage monitoring and alert solution. It ensures early detection of hazardous gas conditions, provides immediate local warnings, and enables remote notification with location details, making it suitable for domestic, commercial, and industrial safety applications.

VI. CONCLUSIONS

The **Real-Time Prediction of Toxic Gases in Underground Drainage** presented in this project represents a comprehensive and reliable approach to ensuring safety in domestic and industrial environments through continuous gas monitoring and real-time alerting. Traditional gas detection methods often rely on standalone detectors or manual inspection, which may not provide timely alerts or remote notification during emergency situations. This system addresses those limitations by integrating intelligent sensing, automated decision-making, and both local and remote alert mechanisms, thereby enhancing overall safety and responsiveness.

The system architecture is designed to be modular, scalable, and efficient, consisting of multiple functional blocks including gas sensing units (MQ2 and MQ3), the ESP32 microcontroller, threshold evaluation logic, alert generation modules, and optional communication and display interfaces. The gas sensors continuously monitor the surrounding air for the presence of combustible or harmful gases and convert gas concentration into electrical signals. These signals are processed by the ESP32, which compares real-time values against predefined safety thresholds to determine hazardous conditions. The use of programmable thresholds ensures flexibility and adaptability for different environments and gas sensitivity requirements.

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