

AI-Based Smart Gas Leakage Detection and Prediction System

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Abstract— *The increasing use of combustible gases such as LPG and methane in domestic and industrial environments has raised serious safety concerns due to potential leakage hazards. Traditional gas detection systems operate on fixed thresholds and lack predictive intelligence, resulting in delayed alerts and increased risks. This paper presents an AI-based smart gas leakage detection and prediction system that utilizes machine learning techniques to analyze real-time and historical sensor data. The proposed system not only detects gas leakage at an early stage but also predicts potential risks before they become hazardous. By integrating gas sensors, environmental parameters, and intelligent algorithms, the system ensures improved safety, reduced false alarms, and proactive risk mitigation. The solution is cost-effective, scalable, and suitable for residential and industrial applications.*

Keywords— *Gas Leakage Detection, Machine Learning, IoT, Predictive Analysis, Safety System, MQ-2 Sensor.*

I. INTRODUCTION

The rapid growth of urbanization and industrialization has significantly increased the use of combustible gases such as LPG, CNG, methane, propane, and butane across residential, commercial, industrial, and transportation sectors. These gases are widely preferred due to their high energy efficiency, convenience, and cost-effectiveness, supporting essential activities like cooking, heating, manufacturing, and power generation.

However, their extensive usage also introduces serious safety risks when leakages occur. Gas leaks can lead to fires, explosions, suffocation, and environmental pollution, resulting in loss of life, property damage, and economic impact. Detection is particularly challenging because many gases are colorless and odorless, and even odorized gases may go unnoticed in confined spaces, noisy environments, or during prolonged exposure that causes sensory fatigue. Slow or minor leaks can accumulate over time, creating highly hazardous conditions with minimal warning. Conventional gas detection systems rely on fixed threshold limits and are reactive, often triggering alarms only after dangerous concentrations are reached. They are also prone to false alarms and lack predictive intelligence. To overcome these limitations, this project proposes an AI-based smart gas leakage detection and prediction system that analyzes real-time and historical sensor data to detect anomalies early and predict potential risks. This proactive approach enables timely preventive actions, significantly enhancing safety and reliability across various environments.

II. EXISTING SYSTEM VS. PROPOSED SYSTEM

A. Existing System Analysis

Existing gas leakage detection systems mainly rely on sensors such as MQ-2 or MQ-6 to detect the presence of gas in the air. These systems work based on fixed threshold values, meaning they trigger an alert only when the gas concentration exceeds a predefined limit. While these systems are useful for basic detection, they have several limitations. They are reactive in nature and cannot predict gas leakage before it becomes dangerous. They also do not analyze historical data or environmental conditions, which reduces their accuracy. In addition, factors like temperature and humidity can affect sensor readings, leading to false alarms or missed detections. Even when IoT features are added for remote monitoring, the core functionality remains the same. These drawbacks highlight the need for a more advanced system that can provide early detection and prediction.

B. Proposed System Framework

The proposed system is an AI-based smart gas leakage detection and prediction system designed to overcome the limitations of traditional methods. It continuously collects real-time data from gas sensors along with environmental parameters such as temperature and humidity. This data is processed and analyzed using machine learning algorithms to identify normal and abnormal patterns. The system is trained using historical data, which helps it understand typical gas behavior and detect unusual changes. When an abnormal pattern is detected, the system generates an early warning before the gas concentration becomes dangerous. This proactive approach helps in preventing accidents and improving safety. The system also reduces false alarms by considering environmental factors and adapting to different conditions. It is designed to be cost-effective, reliable, and suitable for both home and industrial use.

III. METHODOLOGY

A. System Architecture

The system architecture is designed to ensure smooth data flow and accurate prediction. It consists of several interconnected components that work together. The gas sensor collects real-time data from the environment and sends it to the processing unit. The data is then cleaned and processed to remove noise and errors. After preprocessing, the data is given to the machine learning model, which analyzes it and predicts the risk level of gas leakage. Based on the prediction, the system generates alerts through alarms or notifications. The architecture also includes a database to store historical data for future analysis. This structured design ensures continuous monitoring, fast response, and reliable performance. In addition, the system supports real-time communication between components, which helps in delivering instant alerts to users. The modular design makes it easy to upgrade or expand the system by adding more sensors or improving the prediction model.

B. Data Preprocessing and Feature Engineering

The methodology of the system involves several steps to ensure accurate detection and prediction of gas leakage. First, data is collected from gas sensors along with environmental parameters such as temperature and humidity. This raw data is then preprocessed to remove noise, handle missing values, and convert it into a suitable format for analysis. After preprocessing, the data is used to train machine learning models such as Logistic Regression or Random Forest. These models learn the patterns of normal and abnormal gas behavior. Once trained, the model is used to analyze real-time data and predict the risk level. If the system detects abnormal patterns, it generates alerts to warn the user. This step-by-step approach ensures that the system provides accurate and timely predictions.

C. Algorithmic Integration

The system evaluates performance across several classification models, including:

- **Random Forest:** A combination of multiple decision trees that reduces overfitting and provides higher accuracy in classifying gas leakage patterns.
- **Logistic Regression:** Used as a baseline model to predict categorical outcomes by estimating the probability that a given sensor reading represents normal or abnormal gas concentration.
- **Decision Tree:** A rule-based model that classifies gas sensor readings into risk categories for early alert generation and preventive action.

IV. SYSTEM IMPLEMENTATION & DESIGN

A. Frontend and Backend Development

The system is implemented using both hardware and software components. The hardware includes gas sensors such as MQ-2 or MQ-6, which detect gas concentration in the environment. These sensors are connected to a processing unit such as a microcontroller or computer. The software part is developed using Python, which is used for data processing and machine learning. Libraries such as Pandas and NumPy are used for handling data, while Scikit-learn is used for building machine learning models. The backend is developed using frameworks like Flask, and the frontend is designed using HTML, CSS, and JavaScript to display data and alerts. The system works in real time and can also store data for future analysis.

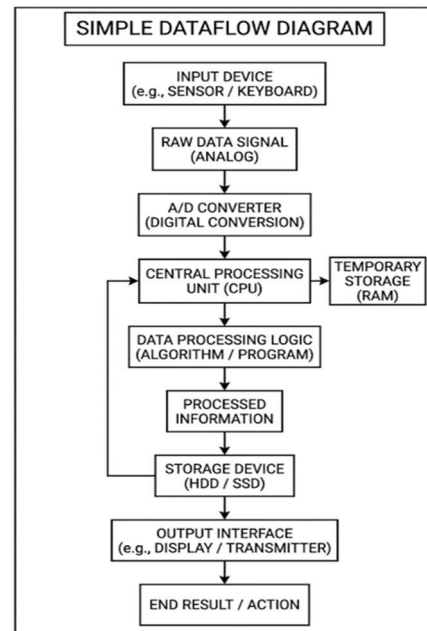
B. System Specification

- **Hardware:** Gas sensors MQ-2 or MQ-6 connected to a microcontroller or computer processing unit. Sufficient storage is needed for data logging, model inference, and system operation.

Software: Python is used as the primary programming language. Libraries such as Scikit-learn, Pandas, and NumPy are employed for model building and data handling. Flask is used for backend development and HTML/CSS/JavaScript for the frontend interface.

V. DATA FLOW DIAGRAM

[Fig. 2: Data Flow Diagram (DFD) — Not Provided]



VI. RESULT AND DISCUSSION

The results of the system show that it performs better than traditional gas detection systems. It is able to detect gas leakage early and predict potential risks before they become dangerous. The system reduces false alarms by considering environmental factors and analyzing data patterns. Graphical results show how gas levels change over time and how the system identifies abnormal conditions.

The machine learning models demonstrated improved accuracy in detecting hazardous conditions:

- **Random Forest:** Achieved the highest accuracy in classifying normal and abnormal gas sensor readings. [Fig. 4: Random Forest Graph]
- **Logistic Regression:** Served as a reliable baseline for binary classification of safe versus unsafe gas concentration levels. [Fig. 5: Logistic Regression Graph]
- **System Output:** The system interface displays real-time gas levels, risk status, and alert notifications. [Fig. 6: System Output Screenshot]

These results indicate that the machine learning model performs reliably in identifying gas leakage patterns. The system provides accurate, timely predictions and enhances safety and ensures quick response in case of gas leakage.

VII. CONCLUSION AND FUTURE ENHANCEMENT

The AI-based smart gas leakage detection and prediction system provides an effective solution for improving safety in environments where gases are used. By combining sensor technology with machine learning, the system can detect gas leakage early and predict possible risks. This proactive approach reduces the chances of accidents and improves overall safety. The system is reliable, efficient, and suitable for real-world applications. It represents a significant improvement over traditional gas detection methods and can play an important role in preventing hazardous situations.

A. Future Work

Future enhancements could include the integration of advanced techniques such as Artificial Neural Networks (ANN) or Long Short-Term Memory (LSTM) models for more complex pattern recognition. Incorporating real-time weather data through external APIs and developing a mobile application would further increase accessibility for users. Additionally, the integration of IoT-based sensors could automate data collection, reducing manual input and improving data accuracy.

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