AlphaTitan - An Advanced Multi-Tasking Autonomous AI Assistant for Real-Time Environment Monitoring and Safe

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In today's world, in terms of industrialization, ensuring safety against potential hazards like gas leaks and fire outbreaks is critical. As a safety measure, this study implements "AlphaTitan," an intelligent, real-time hazard detection system developed to provide accurate detection and timely alerts for enhanced safety in industrial, residential, and public environments to prevent disasters. This system uses sensors that can detect and identify the harmful gases and potential fire hazards, which are the main causes of industrial accidents and health risks in today's world. After detecting any hazard de, this system instantly triggers alerts, locates the hazard's real-time location, and also alerts the owner or emergency department by sending the real-time notifications via social media communications systems, like WhatsApp. In addition to this, our system also captures images and records videos of fire hazards. By integrating advanced sensor-based detection technology with IOT devices, Our System "AlphaTitan" provides a reliable, scalable, and affordable solution for safety management, decreasing risks.

Keywords: Gas Leaks, Fire Detection, Sensors, Internet of Things

Introduction:

Ensuring safety, which includes being aware of potential risks and hazards that could endanger people, property, and the environment, is one of the most crucial aspects of human life. Among these risks, gas leaks and fires are especially hazardous in residential and commercial settings. Gas leaks are frequently imperceptible to the human senses because of their nonexistent odor, especially when they originate from compounds like LPG and methane. These leaks have the potential to cause hazardous events like fire outbreaks and explosions. A small fire element contact may produce a large explosion because LPG is a highly flammable gas[1]. Similar to this, fire outbreaks can result in irreparable property damage, fatalities, and environmental destruction in a matter of minutes if they are not promptly detected and contained. These difficulties and risks are necessitating the development of sophisticated safety systems that can identify threats in real time and send out alarms right away. Gas leakage techniques, trends, and sensors are constantly evolving, and developers and researchers need to stay up-to-date on the latest advancements [2].

"AlphaTitan" is an advanced, adaptable system designed to address these safety issues by utilizing cutting-edge technology, including artificial intelligence (AI), the Internet of Things, and improved sensing techniques. Our system features gas detectors to identify hazardous substances, including LPG and Methane, along with fire alert systems that can recognize fire threats through temperature variations, smoke detection, and visual analysis. Upon detecting a threat, our system promptly triggers alarms, captures images, records footage, and monitors the live location of the event. Alerts are dispatched via WhatsApp, SMS, and other connected platforms to ensure timely responses from the relevant personnel.

Through the integration of state-of-the-art sensors and real-time communication networks, AlphaTitan provides a flexible and affordable solution to satisfy the urgent safety requirements in residential, commercial, as well as public areas. This approach not only ensures timely action but also reduces risks and potential dangers and fosters a more secure atmosphere. The introduction of AlphaTitan marks a significant development in revolutionizing safety surveillance systems in a time when intelligent, automated fixes for the detection and prevention of hazards are increasingly becoming more and more important.

Literature Review:

Systems for detecting fire and gas have the responsibility of averting these potentially lethal situations and property damage. Conventional systems rely on discrete sensors that frequently arrive quickly to deliver pertinent data or to start emergency responses right away. To enhance detection and prevention capacities, researchers have therefore put up several clever solutions that incorporate cutting-edge technologies like IoT, GSM, and AI.

Similarly, fire damage is an issue in residential and commercial locations since it results in the loss of life and property. An IoT-based smart fire detection system including heat, smoke, and flame detectors was proposed by Alqourabah et al. in 2021. Using algorithms, the system evaluates these detectors to determine the likelihood of a fire and uses GSM modems to notify owners and emergency agencies. Implementing IoT greatly improves response times and asset protection by providing real data without endangering human life. [3].

Similarly, Latiff and Mohammad (2021) used Arduino and NodeMCU ESP 8266 to create a fire detection and removal system that operates automatically. Their study emphasizes how crucial it is to incorporate automation into fire safety systems, yet despite their shown effectiveness, such tactics have not yet been adopted. [4]. Progressive solutions, like the thermal infrared version for fire identification and monitoring systems, employ data control techniques to deliver near real-time warnings, lowering false alarms and enhancing system efficiency, claim [5].

Significant issues with dangerous gas leaks are addressed by recent developments in gas detection devices. For remote data logging and monitoring, [6] created a gas detection system

that is connected with ThinkSpeak. With the help of an Internet of Things (IoT) technology, gas concentration levels can be continuously monitored, allowing for real-time maintenance and risk mitigation. [6]. A system was developed by [7] to detect methane and LPG leaks in home settings and notify users to lessen any risks. In these circumstances, the use of sensors and IoT technologies enables quick intervention. [7].

Similarly, [8] developed a GIS-based gas leak detection system that combines GSM and Arduino Nano technologies. This system autonomously identifies potential hazard scenarios and notifies the owner via SMS and phone call, ensuring prompt alerts and actions. [8]. [9] underscored the commercial implementation of gas detection systems, concentrating on methane gas leak identification utilizing short-infrared laser technology. Their research accentuates the possible destruction inflicted by industrial gas leaks, encompassing ecological damage and property loss, emphasizing the necessity for dependable detection systems. [9].

Regarding fire detection methodologies, numerous strategies have been examined and emphasized, incorporating image analysis and advanced learning. [10] investigated flame imagery and sophisticated learning to forecast real-time fire heat release rates, demonstrating the capability of artificial intelligence in improving system precision. [10]. [11] expanded this notion to construction safety, creating a preliminary fire detection framework utilizing computer vision-enabled CCTV for enhanced surveillance and prompt intervention. [11].

Moreover, recent studies conducted by [12][13] provide comprehensive insights into contemporary fire detection systems. This research investigates the incorporation of sensors for identifying elements such as temperature, flames, and smoke, as well as their associated advantages and drawbacks. Such studies highlight the significance of utilizing sophisticated sensing methodologies for enhanced fire management. [12][13].

Objectives:

The objective of this research is

- To develop an affordable, scalable IoT-based hazard system that is capable of detecting real-time fire hazards and gas leakages.
- To enhance safety and security measures, the system ensures comprehensive hazard warnings using voice alerts, buzzers, and LED, while minimizing false alarms using advanced sensors and AI algorithms.
- To ensure timely alerts and location sharing using real-time communication tools and integration of multi-sensor and automated real alert generation.

Novelty of the Study:

In contrast to conventional systems, AlphaTitan uses open-source hardware (ESP32-CAM, Arduino) at a low cost and integrates sensor fusion with cloud storage and real-time data transfer using WhatsApp. Scalability is made possible by its modular architecture, and future smart analytical capabilities are supported by the AI-ready backend**.**

Recent Fire Tragedies:

Incident	Date	Impact
Fire at Turkiye ski Resort	21 Jan 2025	A hotel fire in a ski resort in northwestern Turkiye has killed at least 76 people, and adding that 51 others were injured. [14]
3 Killed at massive fire in Pakistan's largest southern city of Karachi	06 Dec 2023	A massive fire broke out Wednesday at a multi-story commercial building in Pakistan's largest southern port city of Karachi, killing at least three people and damaging several shops, police said. [15]
Pakistan: shopping mall fire in Karachi	25 Nov 2023	At least 11 people have been killed and 35 injured in a fire at a shopping mall in Pakistan's commercial capital of Karachi. [16]

Methodology:

Overview:

The proposed methodology is used to build a real-time fire and gas detection system called Autonomous AI Assistant for Real Time Environment Monitoring and Safety using IoT-based technologies. Our System is designed to ensure reliability, scalability, and affordability. Reliability is ensured by using multiple sensors to verify data before generating alerts. Scalability is achieved by using modular components and enabling the expansion of numerous users and locations. Affordability is achieved by Cost-effective components such as Arduino Uno and ESP32-CAM, open-source and free cloud services, or software. Our System is capable of detecting variables such a temperature, smoke, flame, and gas concentration levels, which a processed by Arduino UNO. The system is also generating alerts and sending real-time data with images, videos, and location based on pre-defined thresholds and transmitted data via communication services like WhatsApp and IOT devices to relevant stakeholders for timely intervention.

The following flowchart represents the internal working of the proposed system.

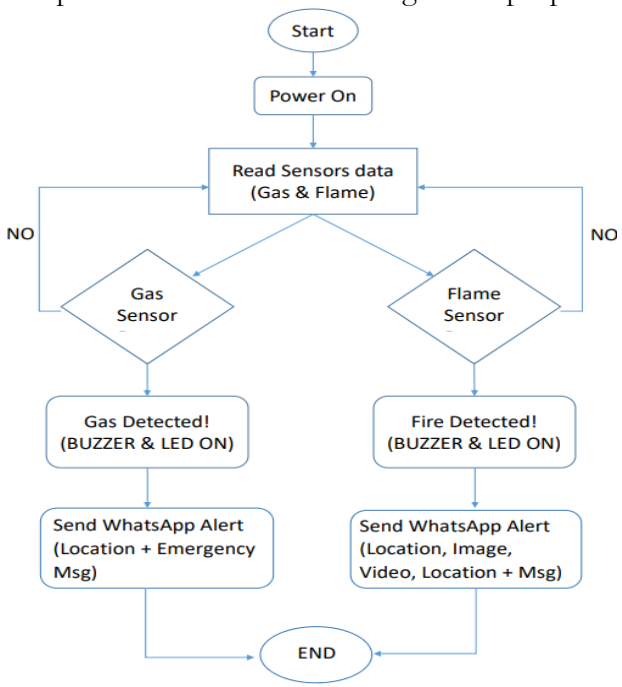

Figure 01: The Flowchart of the Proposed System

Flowchart Explanation:

Sensor Activation: Starting from the activation of sensors. The sensors (gas and flame) continuously monitor the environmental conditions.

Data Processing: The Arduino Uno continuously reads the data that comes from sensors, if any hazard is detected, and compares it with defined safety thresholds.

Trigger Alert:

- If defined thresholds are breached, then Arduino activates the buzzer and LED.
- The ESPCAM-32 Module captures images and videos of the hazard**.**
- The GPS Module (Neo06M) captures the location of the hazard.

Communication:

- The backend logic that is developed in Python via VS Code receives the hazard data through serial communication.
- The system sends a notification containing the images, videos, and location of the hazard with the sensor's data through the WhatsApp API.

Backend Code Logic:

The backend code is written in the Python programming language, and it processes the real-time data and generates the alerts.

Data Receiving:

The Arduino Uno sends real-time sensor data through serial communication. Python code reads and processes that data using the "serial" library and analyzes it for evaluation.

Threshold-Based Processing:

If data is received, it is checked against predefined threshold values, and the threshold checks are implemented in Python using conditions and loops.

Alert and Media Handling:

- Upon Detection, the ESP32-CAM module captures the image and records a short video.
- Real-time location coordinates (latitude and Longitude) are provided by the Neo-6M GPS Module.
- Python code receives this information and sends the WhatsApp message containing (Alert type Gas/Flame, Timestamp, Location, and image or video) using the Twilio API library.

Data Logging & Storage:

Sensor reading, time, image path, location, and other alerts are stored in a MongoDB Database for future analysis.

Multithreading and Automation:

Libraries like threading and time are used to manage concurrent processes such as receiving data, delivering alarms, and storing in the database without any delay.

This backend logic ensures fast decision-making, real-time responses, and proper data storage.

Implementation:

Circuit Diagram:

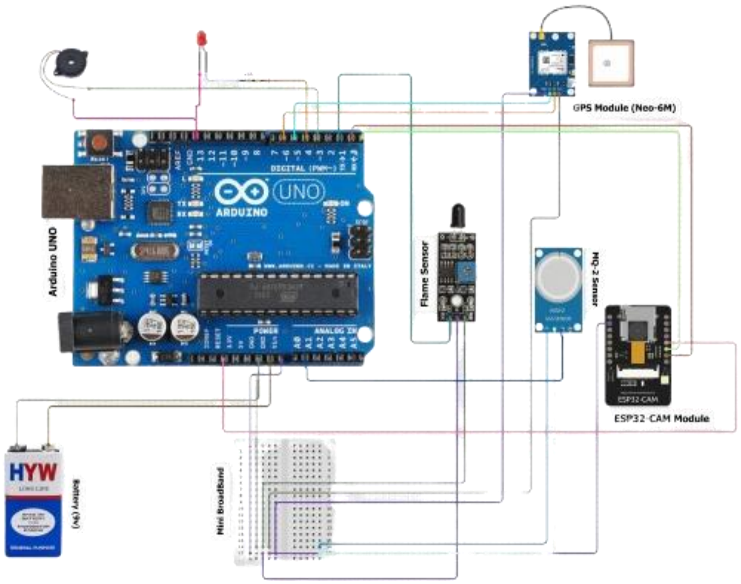

Figure 02: Circuit Diagram of the Proposed System

System Components:

Flame Sensor: This sensor detects the presence of fire by identifying infrared radiation emitted by flames.

Figure 03: Flame Sensor [17]

MQ-2 Sensor: This sensor identifies gases.

Figure 04: MQ-2 Sensor [18]

Arduino Uno: This is the brain of our system, called microcontroller that processes sensor data and control system components.

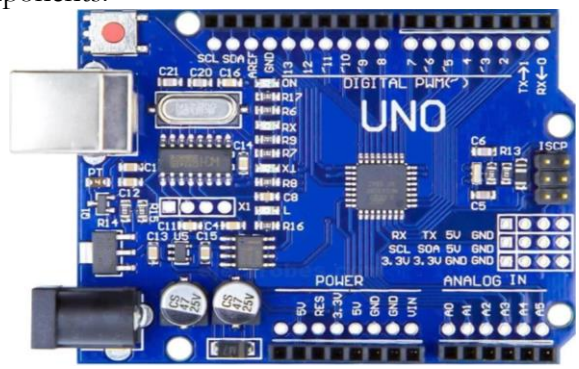

Figure 05: Arduino Uno [19]

ESP32-CAM Module: This module captures and sends images.

Figure 06: ESP32-CAM Module [20]

GPS Module (Neo-6M): Provide real-time location latitude and longitude data.

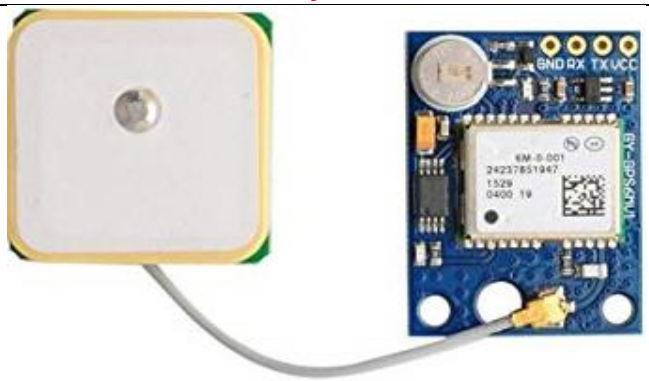

Figure 07: GPS Module (Neo-6M) [21]

Buzzer: When fire and gas are detected, the buzzer will emit an alarm to notify users to take action.

Figure 08: Buzzer [22]

Figure 09: LED Indicator [23]

LED Indicator: Provide a visual alert when a hazardous condition is detected.

Software Configuration:

Arduino IDE (C++): This software is used to program the Arduino Uno, define thresholds, read sensor data, and communicate with ESP-CAM 32 and GPS Modules.

VS Code (Python): This software handles the serial communication from Arduino, real-time processing of the sensor data, and integration of the WhatsApp API for sending the images, videos, and location alerts using Python Programming Language.

Python Libraries Used:

Library	Purpose
pygame	Used for Audio playbacks (e.g., alerts)
moviepy.editor	Used to handle the captured images and videos from ESP32-CAM
pyfirmata	Used for communication between Python programming and Arduino via the Firmata protocol
serial	Reads real-time sensor data sent from Arduino Uno via USB port
Twilio. rest	Send WhatsApp messages using the Twilio API.

MongoDB: This software is used to store the real-time sensor data, captured images, and videos of the hazard and location, as well as for future analysis and predictions.

Working Principle:

The proposed system is developed to detect gas leaks and hazards in real real-time environment using an MQ-2 gas sensor, a flame sensor, an Arduino Uno microcontroller (brain), a buzzer, an LED indicator, and IoT-based communication functionality. The system runs continuously and monitors the surrounding environment for the presence of gas leakage or flames.

Once the system is powered on, the MQ-2 gas sensor and the flame sensor start their work by analyzing air composition and detecting any presence of gas leakage or fire. When the gas sensor analyzes the air and identifies an unusual concentration of gas going out of threshold, then the system not only activates the buzzer and LED indicator but also sends the real-time

location to its owner and the fire department. Similarly, the flame sensor detects fire radiation and it will generate an alert through buzzer and LED indicator, and also sends the images of fire with real-time location to the owner and the fire department.

The entire system works continuously to allow real-time monitoring through WhatsApp notifications, enabling on-time decision-making and quick action against potential disasters. By integrating advanced sensors, real-time alerts and IoT-based communication, this system is capable of safeguarding lives and minimizing property damage by integrating advanced sensors, real-time alerts and IoT-based communication.

Results:

Table 1: Threshold Gas Detection

MQ-2 Sensor Gas Analysis	System Response
< 250	No Gas Detection
≥ 250	Gas Detected

Visualization of Gas Concentration:

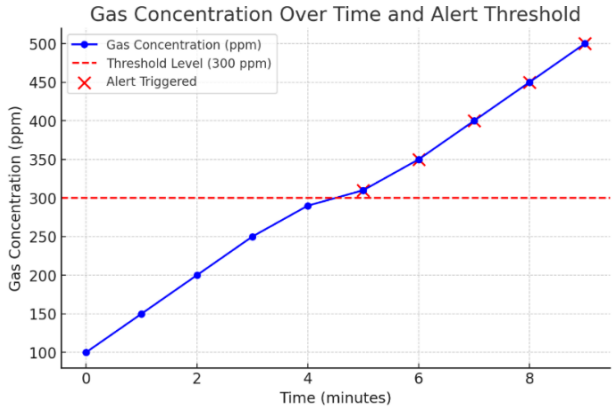

Figure 10: Visualization of Gas Concentration through Line Chart

TABLE 2: Threshold Fire Detection

Flame Intensity (Sensor Value)	System Response
< 300	No Fire Detected
≥ 300	Fire Detected

Visualization of Gas Concentration:

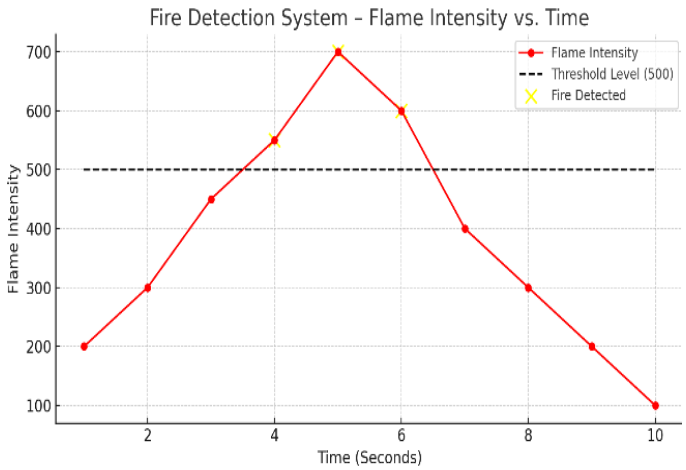

Figure 11: Visualization of Fire Concentration through Line Chart

The system is not fully implemented yet, but its initial testing confirms that it was super reliable, highly scalable, and cost-effective. It detects dangers instantly and also provides real-

time monitoring by using multiple sensors, automated alerts, and IoT-based communication, making it a great choice for environmental safety.

Reliability:

Multiple sensors have been used to maintain the system's reliability, such as the MQ-2 gas sensor and flame sensor, which detect gas leaks and fire risks. For each sensor, a specific threshold is set (250 PPM for gas and 350 units for flame intensity) to ensure that the alerts are triggered only for the actual threats. Additionally, automated alerts like the ESP32-CAM are used for capturing images, recording videos, and sending GPS coordinates via WhatsApp to reach authorities and contributors. This approach enhances the system's accuracy and dependability.

Scalability:

The system is designed to allow expansion without major modifications. Adding more sensors increases the coverage area, enabling the detection of gas leaks and hazards in industrial, residential, and commercial settings. Integration with cloud storage solutions, MongoDB, and IoT platforms (Blynk, ThingSpeak) enables real-time data storage, efficient analysis, and supports centralized monitoring and remote access. In the future, AI-powered predictive analysis will be incorporated to enhance scalability and effectiveness, allowing the system to predict hazards in advance and prevent incidents.

Affordability:

Making the system affordable for everyone, low-cost microcontrollers like Arduino Uno and ESP32-CAM are used, which work efficiently on a low budget for processing and provide IoT communication. Open-source software like Arduino IDE, Python, and WhatsApp API is used to save extra licensing costs. The modular design of the system makes maintenance and upgrades easier while also minimizing long-term expenses. This approach makes the system cost-effective and an effective solution for gas and hazard detection.

Discussion:

The Proposed system AlphaTitan provides a multi-sensor and real-time technique for environmental monitoring with emphasis on gas leak and fire detection. When compared with existing studies, AlphaTitan shows promising outcomes. For example, [1][2] developed an IoT-based solution for gas and LPG leak detection using basic sensors and cloud computing. However, this system lacked features like GPS-based location sharing and real-time media transmission, and they were only capable of gas detection.

In contrast, AlphaTitan integrates both gas and flame detection using MQ-2 and flame sensors and includes an ESP32-CAM module for capturing real-time images and videos of the hazardous site, which is not implemented in systems like those of [6][7].

Other studies, such as [3][4], also suggested an IoT-based fire detection system with an automatic alert mechanism, but they could not detect and cross-verify many environmental factors simultaneously. AlphaTitan addresses this by incorporating a multi-sensor validation system to improve reliability.

Recent advancements in fire detection using computer vision and AI [11][10] focused on high-end, infrastructure-heavy systems for urban environments. However, our system is affordable and deployable in rural and low-resource areas, making it more accessible and practical.

Furthermore, [5] suggested real-time detection using thermal sensors, which is precise but expensive. AlphaTitan offers an affordable solution by using open-source software and low-cost hardware like the Arduino with respectable performance levels.

For a novelty study, AlphaTitan stands out in terms of:

- WhatsApp-based alerting system with possible cloud connection.
- Low-cost hardware design for deployments with a low budget.
- Real-time multimodal monitoring using GPS location, video, and images.

Thus, AlphaTitan advances existing research by offering a real-time environmental safety system that is multifunctional, scalable, and affordable. It is based on technologies that are easily accessible and have a high potential for practical use.

Conclusion:

A prototype of real-time gas detection and fire detection was developed. This system is capable of detecting gas leaks and fire hazards using MQ-2 gas sensors, flame sensors, an Arduino Uno microcontroller, and IoT IoT-based communication system. Our system continuously monitors the surrounding environment and ensures early detection of potential dangers. When our system detects a hazard then it alerts its nearby persons with a buzzer and LED indicator, and also sends the real-time data like images, videos, and location to the owner and security authorities.

Future Work:

Integrating Artificial Intelligence and machine learning algorithms can enable our system to predict sensor data to predict and hazards before they occur and send early warnings. Additionally, an automatic fire suppression system will be integrated, such a sprinklers and extinguishers, that can be activated upon fire detection.

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