As per UGC guidelines an electronic bar code is provided to secure your paper

International Journal for Modern Trends in Science and Technology
Volume 12, Issue 03, pages 50-58.
ISSN: 2455-3778 online
Available online at: http://www.ijmtst.com/vol12issue03.html
DOI: https://doi.org/10.5281/zenodo.18880518

IoT - Based Fire and Gas Leakage Detection System Using AI

D. Vijendra Kumar[1], Manda Naga Bhuvana Chandrika[2], Yarnagula Iswarya Lakshmi[2], Varanasi Padma Veera Venkata Sriteja[2], Dammu Jyothsna[2]

Department of ECE, Godavari Global University, Rajamahendravaram, INDIA.
Department of ECE, Godavari Institute of Engineering & Technology (A), Rajamahendravaram, INDIA.

To Cite this Article
D. Vijendra Kumar, Manda Naga Bhuvana Chandrika, Yarnagula Iswarya Lakshmi, Varanasi Padma Veera Venkata Sriteja & Dammu Jyothsna (2026). IoT - Based Fire and Gas Leakage Detection System Using AI, 12(03), 50-58. https://doi.org/10.5281/zenodo.18880518

Article Info
Received: 28 January 2026; Revised: 26 February 2026; Accepted: 02 March 2026.

KEYWORDS

IOT(Internet of Things), Raspberry Pi platform, Artificial Intelligence system, YOLO object detection system, Automated Safety System, Real-Time Monitoring system, Cloud Integration system, Thing Speak platform, Embedded Systems technology, and Smart Safety Applications.

ABSTRACT

Fire incidents and gas leaks pose serious risks to human life and can damage property and industrial infrastructure in areas without ongoing monitoring and emergency response systems. Traditional detection systems often produce too many false alarms because they rely on individual sensors that require human input to function. This research presents an Internet of Things (IoT) system that detects fires and gas leaks through continuous monitoring, accurate risk assessment, and automated safety protocols. The system uses temperature, humidity, gas, and smoke sensors, all connected to a Raspberry Pi for real-time environmental monitoring. By combining a YOLO-based deep learning model with a USB camera system, the system can visually detect fires while improving reliability and reducing false alarms. It activates safety equipment such as exhaust fans and gas shutdown systems when it identifies hazardous conditions. Additionally, the system sends immediate alerts through a buzzer. A cloud-based IoT platform collects sensor data and system status information, allowing for remote monitoring. Experimental tests show that the system performs well for residential, commercial, and public safety needs. It achieves better detection results, faster response times, and operates reliably. The IoT and AI-based fire and gas leak detection system uses a Raspberry Pi along with sensors and YOLO to provide real-time monitoring, accurate detection, automated safety measures, and remote cloud-based monitoring. The detection system operates through remote access to cloud-based solutions.

INTRODUCTION

Fire incidents and gas leaks are the top safety threats in residential buildings, commercial establishments, and public infrastructure. The risk of these events has grown due to increased use of electrical devices, combustible gases, and industrial machinery. Gas and fire accidents can cause significant property damage, loss of life, and environmental harm. Early detection and quick response are crucial to reducing these impacts. Traditional safety systems do not offer ongoing monitoring or immediate response capabilities. Intelligent safety solutions that operate autonomously in real-time should become standard practice as urban development and industrial growth continue to increase.

Traditional systems for detecting fire and gas hazards depend on independent sensors which have limited detection capabilities that include gas detectors and smoke detectors. The system operates through local alarm systems which need human operators to implement system corrections. The system encounters multiple false alarms because environmental conditions, which include dust and steam and humidity changes and temperature fluctuations, interfere with its operation. The system errors lead to two negative outcomes which include user trust reduction and system reliability decrease. The lack of remote monitoring capability in most traditional systems creates difficulties for assessing emergency situations which occur when the property remains unmonitored. The absence of automated safety measures, which include gas shutoff and ventilation control, leads to two negative outcomes because it increases the severity of hazardous situations and it hinders emergency response efforts.

The rapid growth of the Internet of Things (IoT) has led to smart monitoring systems that rely on continuous data collection, system communication, and process control. IoT safety systems use various sensors and embedded platforms to monitor environmental conditions. They send data to cloud dashboards, giving remote access to users. The system can carry out emergency safety procedures automatically, without human help. However, sensor-only IoT systems still face issues. They often produce false alerts and struggle to grasp their actual surroundings. To improve detection in complex situations and protect sensor information, the system needs to have intelligent decision-making abilities.

Artificial intelligence (AI), especially deep learning-based computer vision methods, offers an effective way to improve danger detection accuracy. By combining IoT sensor data with AI models like YOLO for visual fire detection, we can create a multi-layered safety system that performs reliably. Fire incidents can be confirmed through visual evidence, which reduces false alarms and increases response precision. Merging AI with IoT and embedded control allows automated alarm systems to establish safety protocols and conduct real-time cloud monitoring. This system delivers a complete solution for fire and gas detection. It addresses the shortcomings of traditional detection systems with its scalable and cost-effective technology, suitable for residential, commercial, and public safety use..

LITERATURE SURVEY

Researchers have conducted several studies on IoT-based fire and gas detection systems that use embedded platforms and environmental sensors. These systems provide continuous monitoring with temperature sensors, humidity sensors, gas sensors, and smoke sensors that connect to microcontrollers or single-board computers. The system generates alerts when sensor readings exceed set limits and sends data to cloud platforms for remote observation. The new operating methods improved system automation and accessibility compared to traditional alarm systems. However, these systems did not include cognitive verification procedures to ensure reliable threat detection. Operators relied on fixed thresholds, which led to false alarms triggered by environmental changes [1]-[4].The system needs better performance and easier access to remote locations. The system needs wireless networks and cloud services which have become common for this purpose. The researchers used Wi-Fi and GSM together with IoT dashboards to create systems which display live data and send out alarm notifications. The systems received two basic automation components which included gas shutdown systems and exhaust fans and buzzer alarms. The systems used sensor data as their primary information source because the upgrades did not improve emergency response capabilities. The system could not identify actual threats because it lacked advanced decision-making capabilities which hindered its ability to recognize environmental changes that did not pose risks [5]–[8].

Several studies used sensor data and machine learning techniques to address the issues of threshold-based detection. The researchers suggested using classification models along with sensor fusion techniques to improve detection accuracy and lower false positive rates. These methods performed better than traditional systems, especially in tough operational environments. The system needed a lot of training data and careful calibration. The embedded hardware for running the model limited the complexity, which led to reduced real-time performance and scalability [9]-[12].

The use of deep learning models sparked more interest in visual systems for detecting fires. Researchers employed YOLO-based architectures and convolutional neural networks to spot smoke and fire in video streams. Their methods achieved two results. They provided quick response times and maintained high accuracy in detection. The system became more reliable by integrating visual confirmation and IoT sensor data, which reduced false alarm rates. However, two main issues remained: additional processing requirements and challenges with hardware and lighting conditions [13]-[16].Researchers currently investigate integrated safety systems which combine Internet of Things technology with artificial intelligence capabilities to provide safety warning through cloud monitoring and automatic safety response and deep learning visual recognition and multi-sensor monitoring system. The implementation of edge computing together with lightweight artificial intelligence models leads to improved real-time decision-making capabilities because of its reduced latency. The experiment results show that the system achieves higher reliability together with faster response times and improved detection accuracy. However, the field needs more research because of problems that exist with real-world validation and standard evaluation methods and extended usage of the system [17]–[20].

PROPOSED METHODOLOGY

The proposed system combines IoT, artificial intelligence, and embedded control systems to create an automated system that detects gas and fire leaks. The environmental sensors in the monitored area constantly observe the temperature, humidity, gas levels, and smoke detection. The system connects these sensors to a Raspberry Pi, which acts as the main processing and control unit. The Raspberry Pi continuously collects sensor information and checks the data against safety standards to identify any unusual occurrences. This ongoing monitoring system allows for quick detection of dangerous situations and lays the groundwork for an effective and self-sufficient safety monitoring system.

The system contains a camera-based visual detection module which works together with its sensor-based monitoring system to enhance its reliability. A USB webcam connected to the Raspberry Pi system enables the system to transmit live video feeds of its surrounding environment. A deep learning model based on YOLO detects fire or flame patterns in video frames which scientists recorded under various lighting and environmental conditions. The system uses visual confirmation as a secondary validation method which works together with the sensor data. The dual-detection system improves hazard detection accuracy while increasing system reliability because it decreases false alarms which occur from dust and steam and temperature variations.

The proposed system uses IoT, artificial intelligence, and embedded control systems to create an automated approach for detecting gas and fire leaks. The environmental sensors in the monitored area constantly watch the temperature, humidity, gas levels, and smoke. The system connects these sensors to a Raspberry Pi, which serves as the main processing and control unit. The Raspberry Pi collects sensor data continuously and checks it against safety standards to spot any unusual events. This ongoing monitoring allows for quick detection of hazardous situations and sets up an effective, self-sufficient safety monitoring system.

The system connects to a cloud-based IoT platform for data analysis and remote supervision. The Raspberry Pi system regularly sends sensor data, detection information, and control commands to the cloud for real-time monitoring and visualization.

The system lets users access historical data for analysis while monitoring operations from remote locations. Combining local intelligence with automatic safety measures and cloud connectivity creates a safety solution that is scalable, cost-efficient, and effective for residential, commercial, and public infrastructure use.

The system starts its safety protocols when it detects a fire or harmful gas. The DC motor pump activates the water sprinkler system to put out fires upon detection. It sends an alert message to the owner's registered mobile number when it finds a fire or gas leak. The alarm message gives emergency responders two key details: the exact location from the GPS module and the current danger assessment. The owner can use an IoT dashboard to monitor the current temperature and gas concentration levels in real-time. The system improves safety and reliability by continuously monitoring activities, providing immediate alerts, tracking locations, and using its built-in systems to handle emergencies through a mix of GPS, GSM, and IoT technologies.

A. System Architecture

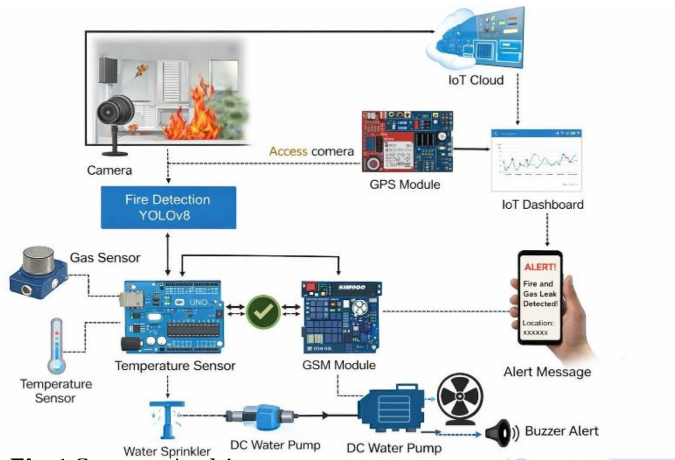

Fig.1 System Architecture

B. Methodology

Information Collection and Monitoring the Environment Using Numerous Sensors

The proposed system uses multiple sensors to track environmental conditions related to fire and gas hazards. It employs temperature and humidity sensors to monitor conditions that indicate fire risk, along with MQ series gas sensors to detect dangerous and flammable gases. These sensors are installed at specific locations throughout the monitored area to ensure effective coverage and allow for early detection. The system continuously collects data from its main safety sensing layer, enabling real-time monitoring of changes in environmental conditions.

The Raspberry Pi connects all sensor outputs through its analog-to-digital conversion modules and assigned GPIO pins. The external ADC module changes analog signals from gas sensors into digital signals for better processing. The Raspberry Pi takes sensor value readings at specific times and temporarily stores the data for future analysis. This organized data collection process allows for reliable threshold comparison, helping to detect dangers early while keeping data accurate and minimizing errors from noise.

The preprocessing process removes all short fluctuations caused by ambient noise, as well as changes in dust and humidity. The data stability process uses both averaging and validation methods to prepare the data for further analysis. This preprocessing step ensures system reliability because it involves decision-making to focus on only the main environmental patterns. The system increases robustness by using multiple sensor inputs, which reduces reliance on any single sensing parameter.

System Integration & Embedded Control Architecture

The Raspberry Pi acts as the main embedded controller that handles all tasks related to sensing, processing, and actuation. The system works as a unified processing system that combines camera inputs, control modules, and various sensor data. The embedded system architecture offers three key features: low power consumption, real-time responsiveness, and ongoing operational support. The system uses modular design principles that allow users to replace components and expand the system while keeping full operational functionality.

The system uses Python software modules to collect sensor data, process images with AI, and control its actuators. Its modular software design allows subsystems to operate separately while connecting through a shared control system. This design makes future improvements easier by allowing for the integration of more sensors and the development of better AI models, while also simplifying maintenance. The system meets two goals by optimizing module communication, which cuts down on delays and ensures that safety protocols are executed quickly.

The embedded system establishes connections with external IoT platforms to enable remote monitoring. The network interfaces transmit alarm data and detection status and sensor readings to the cloud through secure channels. The integrated design enables smooth operation between all hardware components and software processes and cloud services which creates a reliable and effective smart safety system that can be used in real-world situations.

AI-Enabled Intelligent Monitoring and Detection Software System

The detection method uses two techniques that combine sensor measurements with artificial intelligence to improve accuracy and reliability. The safety system first evaluates sensor data against safety standards to identify abnormal events. These events include high gas levels and sudden temperature drops. The system marks an incident as potentially dangerous when any monitored parameter exceeds its safety threshold. Our detection system has multiple layers to reduce false alarms while detecting hazardous situations early.

The fire detection system includes a camera-based module as an extra method to support better decision-making. The YOLO-based deep learning model detects fire and flame patterns by analyzing live video feeds from the webcam. The system achieves greater accuracy through visual confirmation, which helps reduce false positives caused by environmental disturbances and improves sensor data quality. Combining visual analysis with physical sensing allows for better hazard detection, resulting in more precise outcomes and better context.

The decision module automatically starts its alarm and control procedures after it confirms a dangerous situation exists. The system uses relays to activate exhaust fans and gas shutoff devices, which reduce potential dangers. Audible alarms alert nearby residents. The system carries out its entire decision-making process without any human involvement, allowing for quick emergency responses and stopping dangerous situations from getting worse. This detection and control system improves both system reliability and safety performance.

AI-powered Optical Surveillance System for the Establishment of Fire Proceedings

The optical surveillance system allows for constant visual monitoring of the environment. The Raspberry Pi system uses a USB camera to capture live video streams and processes them locally for quicker video detection results. Optical sensing provides extra verification options, helping the system detect fires through its visual identification even when sensor data is lacking in complex situations.

A YOLO deep learning model detects fires by processing live video streams. It learns to recognize features of flames, such as color, shape, and motion patterns, by training in various lighting conditions. The system quickly detects fire incidents using a separate evaluation method that analyzes each recorded video frame. The model's lightweight design keeps detection accuracy high while allowing it to run on embedded systems.

Final safety judgments come from combining sensor data with visual detection results. The system increases reliability by confirming dangerous events using multiple detection methods. Pairing optical surveillance with post-event analysis offers visual proof that allows for remote monitoring. Integrating IoT sensing with AI-based optical analysis creates a reliable fire and gas detection system that works effectively in safety-critical environments.

Technical Specifications:

Item	Measurement Range	Humidity Accuracy	Temperature Accuracy
DHT11	20-90%RH 0-50^{0}C	±5%RH	±2^{0}C

Table 1 Technical Details

The gas sensors concentration range of 300 ppm to 10,000 ppm enables accurate detection of dangerous situations and gas leaks which occur in residential and commercial environments.

RESULTS

The initial visual material should show the entire experimental setup. This includes all parts from the Raspberry Pi to the connected sensors, camera module, laptop interface, and real-time testing environment. The location is important because it helps users grasp the proposed system in one view. The system development process helps readers see how various software and hardware components work together to create an integrated fire and gas leak detection system. This complete setup demonstration offers clarity, allowing the reader to move on to the detailed technical explanations in later sections of the document.

The system works using live video streaming. This shows all operations, ongoing sensor data collection, AI-based control, and fire detection functions. The system demonstrates complete operational capability by running established software. This software displays live video feeds and uses visual indicators to show the active system status. The AI model was specifically trained for developing prototypes. Its main role was to ensure that the prototype functioned as intended. The researchers performed functional testing to evaluate the model's performance by checking its ability to detect fire under certain conditions. The demonstration confirms system reliability through practical evidence that the approach works effectively.

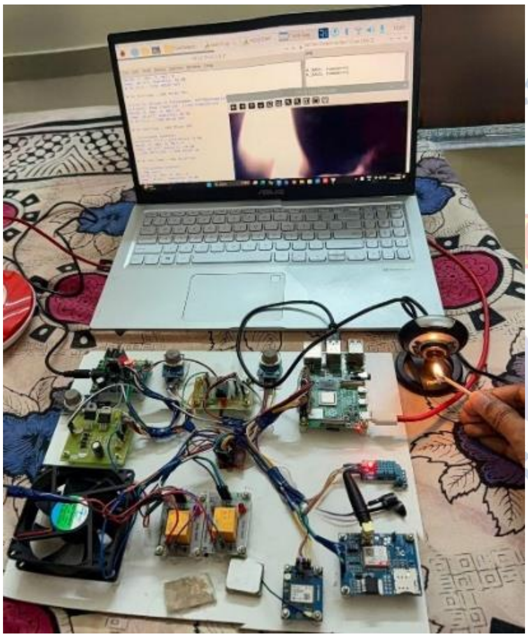

Fig 2 Putting Enhanced Fire and Gas Leak Detection With Integrated IoT and AI System

The research document follows standard academic formatting. It requires researchers to give an overview before diving into their detailed study. This document sets a foundation for future discussions. These discussions will look at ways to reduce risks, decision-making processes, and sensing methods. The complete system model allows readers to understand the later technical details through the explanations provided.

The second placement needs to focus on gas sensors and relay modules along with exhaust fans and their associated circuits. These are essential sensing and actuation parts. The complete system description explains how the system records environmental data and how automated systems react physically to those conditions. The specific details in this section help readers grasp the process of hardware design choices and the operational purposes of each system component.

The material shows how using multiple gas sensors together can improve detection accuracy and provide reliable performance. The relay modules establish a successful link between high-power actuators and low-power control signals. In dangerous settings, visible status indicators show proper signal flow from the controller to the safety devices.

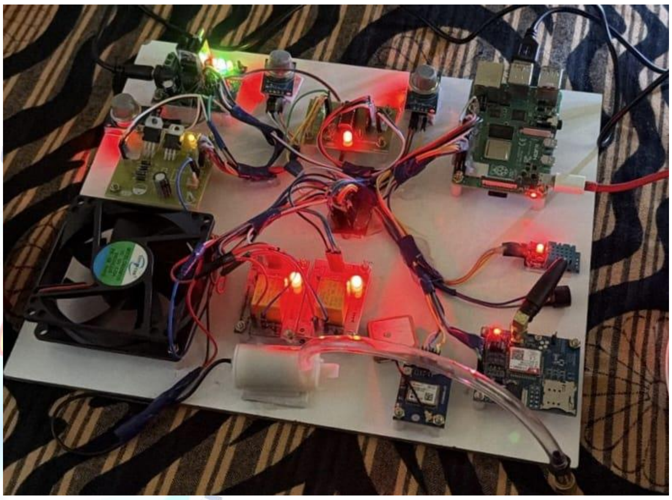

Fig 3 Incorporation of Sensor, Relay, and Actuator

Readers can easily transition from a general system overview to a focused discussion on hardware by placing this content after the overall setup. The system offers clear proof of proper hardware setup and control logic functioning, which confirms the implementation details outlined in the methodology.

The software behavior of the system includes real-time sensor readings, detection status messages, and cloud update alerts. This should be highlighted in the third placement. The section shows how the embedded controller processes raw sensor data by using AI analysis and established logic to make decisions. The system test verifies two elements: continuous system operation stability and data processing pipeline accuracy.

The live camera feed shows how the AI fire detection module works. The system analyzes video frames to confirm if there is a fire before sending out alarms, even in different lighting or motion situations. The system improves its performance with a layered detection method that reduces false alarms and increases reliability.

This content is best placed third because it shifts the focus from hardware to performance outcomes. The results and discussion section of the study provides evidence to back its claims by showing that the proposed algorithms and control mechanisms achieve effective results in real time.

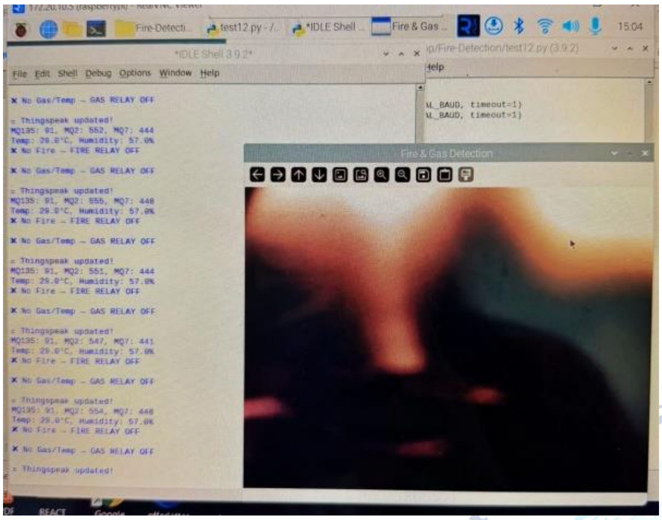

Fig 4 Execution of Software Real-time and Results of Fire Detection

The final placement should show the experimental validation of automated safety systems that include water-based suppression systems and exhaust ventilation systems. The material demonstrates how the system behaves during hazard detection. This leads to the correct and immediate execution of mitigation procedures. The system shows its ability to reduce danger while also detecting potential threats.

The experimental testing shows that relay-controlled devices keep working reliably in conditions that mimic dangerous environments. The system meets its safety needs through the automatic operation of its mitigation elements, which function without human control. Public spaces, commercial areas, and residential locations need this validation method because they require immediate use in emergencies.

The results section receives improved results through this content which delivers proof of its effectiveness in demonstrating study results. The system's operational capacity in real-world situations shows its system reliability and resilience which the reader can verify through this information.

Fig 5 Updates to Sensor Data on ThingSpeak

The graph shows how the recommended system sends real-time sensor data updates to the ThingSpeak cloud platform. The data displayed confirm that the sensing unit and the IoT cloud communicate effectively, with sensor readings uploaded regularly at set intervals. The graph also indicates that data logging is ongoing since the system keeps recording and transmitting sensor data. This setup allows users to monitor environmental conditions from faraway places.

The cloud-based display lets system owners track sensor performance over time. It helps them identify unusual sensor patterns that could signal safety issues. System owners receive alarm notifications only at their registered mobile number if any threshold value goes beyond its set limit. The alert system keeps security in check by blocking unwanted alerts and unauthorized access. It ensures that important information goes only to the right people.

The temperature and humidity changes recorded by the environmental sensors appear in this graph on the ThingSpeak dashboard. The ongoing changes in humidity and temperature show real-time monitoring as external conditions shift. This type of graph helps identify sudden temperature spikes or unusual humidity levels, which may indicate early signs of gas or fire hazards.

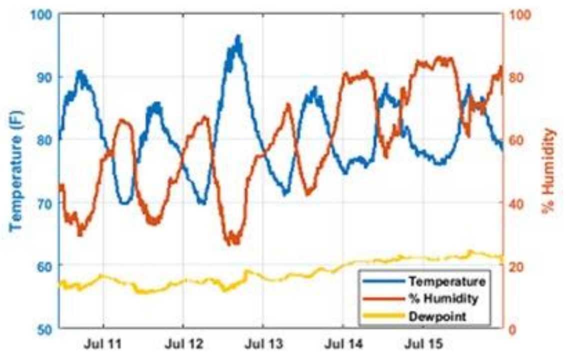

Fig 6 ThingSpeak Temperature and Humidity Monitoring

The dashboard access is restricted to the registered owner which protects both system security and data privacy. The owner can monitor temperature and humidity percentages from any location because the system allows remote monitoring even when they are outside the secured area. The combination of real-time viewing with controlled access creates a system that enables proactive safety management and enhances system reliability.

CONCLUSION

Our work created an IoT and AI-based system for detecting fires and gas leaks. This system aims to improve safety in public spaces, industrial sites, and residential areas. It continuously monitors environmental conditions by using multiple sensors and a Raspberry Pi controller. The system increases its reliability with camera-based fire detection that uses a YOLO deep learning model, providing visual proof of threats. The proposed design offers better safety protection by monitoring situations in real time. This allows for automated decision-making and quick responses without needing human involvement.

The experimental implementation and testing process showed that the sensing and control components worked well. The system consistently gathered sensor data during normal operations and accurately detected fire and gas leak simulations. The AI visual detection system identified fire presence by analyzing live video streams before any action was taken. It used relay control to carry out automated responses, such as turning off gas, activating the exhaust fan, and sounding the buzzer. The system proves it can identify security threats while starting emergency protocols to keep people safe.

The system improved performance with cloud integration, enabling users to monitor data from afar and check system status information. The IoT platform let users see live sensor data, detection updates, and information on the system's operation. This feature boosts situational awareness when operators are outside monitored areas, allowing them to make more informed decisions. The system helps organizations grow their operations with its modular design. They can add more sensors, AI solutions, and new communication methods without making major changes to the system.

The proposed security system offers an effective solution that combines automated control, AI detection, and IoT sensing at an affordable price. It can grow to meet increasing demands. The system works well in safety-critical environments because its independent operation creates fewer false alarms and allows for immediate emergency responses. Future research will help develop reliable and functional systems by testing products in real-world settings. It will also focus on creating AI systems designed for remote locations and establishing connections to emergency response networks.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] The research paper "IoT Based Smart Gas Leakage Detection and Alert System" by S. Shah was published in 2021 through SSRN.

[2] T. Babu, "Improving Gas Leak Identification through IoT Technology," Procedia Computer Science, 2024.

[3] "IoT-based Gas Leak Detection and Fire Hazard Recognition System using Image Processing," ResearchGate, 2025, Md. A. I. Anik et al.

[4] E. Landi, "IoT-Based Gas Detection Sensor Reliability and Performance Evaluation," Electronics, 2025.

[5] International Journal of Innovative Research in Science, "A Gas and Fire Detection System with Autonomous Firefighting and Real-Time Monitoring," 2025.

[6] "IoT-based Cloud Monitoring System for Building Fires," International Journal of Metrology and Quality Engineering, G. Pan, 2025.

[7] "Fire Hazard Warning System in IoT Environment Using 1DCNN," M. M. Akhtar, ScienceDirect, 2025.

[8] IRJMETS, "IOT-BASED FIRE AND GAS LEAKAGE DETECTION SYSTEM," 2025.

[9] The research paper "Real-Time Video-Based Fire Detection Using Deep Learning" by D. H. S. Gujjar will be published in the International Journal of Scientific Research and Modern Technology in 2025.
[10] The research paper "Artificial Intelligence Based Real-Time Smoke and Fire Detection" is scheduled for publication in 2025 according to ResearchGate.
[11] The research paper "A Study of YOLO Architectures for Wildfire and Smoke Detection" will be published on ScienceDirect in 2025.
[12] The research article "DSS-YOLO: Enhanced Real-Time Fire Detection Model" will be published in Scientific Reports in 2025.
[13] The research paper "FCMI-YOLO: Effective Deep Learning-Based Algorithm for Real-Time Fire Detection" by J. Lu et al. will be published in PLOS ONE in 2025.
[14] The study "Fire Detection with Deep Learning A Comprehensive Review" will appear in MDPI Land in 2024.
[15] The study "YOLO-v8-Based Enhanced Fire Detection Method for Smart Cities" will be published in Neural Computing and Applications in 2023.
[16] The study "Smart Gas Leakage Detection Using IoT" will be published in IRJAEH in 2025.
[17] The research paper "A Survey on Gas Leakage Detection and Protection Using IoT and AI" will be published in IJIRSET during 2023.
[18] IJARC, "Smart Home and Industrial Safety Using Fire and Gas Detection," 2025.
[19] "IoT-Based Intelligent Safety System for Gas, Fire, and Multi-Hazard Detection," AIJMR, 2025.
[20] Applied Engineering Innovation and Technology publishes "Internet of Things (IoT) Based Fire Detection and Suppression System" in 2025.