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# A Gas and Fire Detection System Driven by IoT with Autonomous Firefighting and Real-Time Monitoring

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ABSTRACT: Rapid, artificial intelligence-supported surveillance techniques, as well as quick responses, are essential for the protection of infrastructure and the public, particularly in the context of threats posed by fire hazards. Controlled via UNO, A microcontroller constructed utilizing a Bluetooth-loaded motor driver is employed within the system at hand: Bluetooth Manned robots, an autonomous fire spotter and extinguishing IoT-based system. It, alongside the flame sensor, DHT11 sensor, and MQ-2 gas sensor, also functions to detect gas substances put to risk, such as smoke, methane, hydrogen, and LPG. Furthermore, the provision of superior situational awareness is facilitated by an ESP32-CAM module capable of real-time surface monitoring. The unit is designed to actively engage the user by means of the Blynk IoT cloud coupled with Gmail alerts, regularly updating the user's phone. Lastly, a smartphone application developed via MIT App Inventor boosts the ease of access to the unit by establishing Bluetooth connections. The formerly mentioned application enhances the unit in ways that allow for more command, using speed adjustments and multidirectional movement. Lastly, the system employs an automatic flamethrower with nozzles able to rotate 360 degrees to put out any flames in sight, proving to leave no flame unturned. Advanced artificial intelligence and cloud data combined leave individuals with the ability to control everything from a distance, setting them free from the need to be there in person. When paired with a selection of environmental sensors, the Blynk IoT app serves a purpose beyond providing instantaneous access to video streams and sensor data, allowing for a broader and more detailed scope of monitoring one's surroundings. Fire response effectiveness, remote access, and detection are enhanced thanks to this unmatched surveillance technology. The system offers a cost-effective and expandable alternative for responding to fires and providing emergency services in many different places.

KEYWORDS: IoT, Fire Detection, Autonomous Firefighting, Real-Time Monitoring, Arduino Uno, Blynk IoT.

#### I. INTRODUCTION

The threat of fire is a great concern for humans, property, and nature which requires having advanced protective surveillance technologies and quick response mechanisms. Most fire detection systems, however, are usually dependent on smoke and heat sensors, which can be slow to respond. The recent developments in decentralized systems and IoT facilitated the use of smart fire monitoring and self-operating firefighting drones that can detect and put out fires at an early stage [2] [14]. This paper proposes an autonomous gas and fire detection system that uses IoT technology for real-time supervision and fire extinguishing [3]. The system is designed to operate differently from typical fire detection systems where there is reliance on using gas sensors for the detection of smoke, methane, hydrogen, and LPG gas coupled with flame and temperature-humidity sensors. The system's processing unit consists of an Arduino Uno microcontroller and Bluetooth motor drivers for movement. An ESP32-CAM module is used in a realtime video monitoring system to increase awareness of a certain circumstance. Instant alerts are sent out via Gmail notifications and the Blynk IoT cloud when a fire or hazardous gas is detected, allowing the user to take remote action. Through a mobile application developed using MIT App Inventor, the speed and multidirectional movement are accomplished in conjunction with manual control.Additionally, a water pump-powered autonomous fire extinguishing system is used. The system provides precise, adaptable, and economical fire monitoring and emergency response by combining sensor-assisted monitoring, remote control, and real-time video transmission. Combining automated firefighting methods with Internet of Things-based real-time monitoring improves the effectiveness and efficiency of fire threat mitigation [11,12]. The recommended system is designed to function in a range of high-risk fire environments, including residences, workplaces, warehouses, and outdoor spaces. Wireless access, mobile control, and

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real-time video surveillance are some of the ways the system enables users to remotely monitor risky situations and respond quickly. Because an autonomous reaction mechanism is included, fires can be extinguished rapidly even in the absence of human aid. The subsequent sections discuss the system architecture, hardware and software integration, experimental results, and system conclusions.

#### **II. LITERATURE SURVEY**

The authors of the Raut et al. (2024) article talk about an autonomous system made for industrial fire detection and suppression. This system uses inexpensive sensors and ceiling-mounted sprinklers that activate in response to the detection of a fire [18]. Despite the system's economy and efficiency, its inability to provide real-time remote monitoring reduces situational awareness in risky fire situations. Its fixed design also limits its capacity to move around and adjust to changing surroundings. Automation and the Internet of Things have increased fire safety by enabling faster responses without requiring human intervention. The system provides users with capabilities to work on problematic circumstances from a safe distance, including wireless access, mobile control, and real-time tracking.

#### **III. METHODOLOGY**

#### 1. Information Gathering

A fire sensor detects the presence of flames by sensing infrared radiation emitted by combustion. A temperature sensor monitors ambient heat levels to identify abnormal rises that may indicate fire risks. The sensor's resistance-temperature relationship is given by:

Where:

 $Ta = 1 / ((1 / T0) + (1 / \beta a) * \ln (Ra / Ra0))$ (1)

Ta = Temperature in Kelvin

 $T0 = Reference temperature (typically 298K or 25^{\circ}C)$ 

 $\beta a =$  Thermistor constant

Ra = Thermistor resistance at temperature

Ra0 = Thermistor resistance at T0

The fire sensor detects infrared radiation emitted by flames, and the intensity is calculated using the Stefan-Boltzman law, by analyzing fire intensity, the system determines the severity of a fire and activates appropriate safety measures.

(2)

Ia =  $\sigma a \times T4a$ Ia = Radiant Intensity (W/m2)  $\sigma a =$  Stefan-Boltzmann constant Ta =Flame temperature (Kelvin)

#### 2. Data processing and Communication:

The ESP8266 microcontroller collects, processes, and sends sensor data to the Blynk IoT platform. The Blynk dashboard allows users to monitor sensor data, live video feeds, and system warnings in real time. The Arduino Uno may move manually or automatically thanks to the HC-05 Bluetooth connection, which enables the Arduino to receive motor control commands. The system's integration of email notifications will ensure that users receive critical information quickly in the case of an emergency.

#### 3. Identification of Fire and Gas:

A threshold-based detection mechanism is incorporated into the system, meaning that if the fire sensor detects flames that are more intense than a predetermined threshold, an immediate fire alarm will sound. A warning for a gas leak is given if the gas sensor finds harmful gas concentrations that are higher than acceptable levels. In both situations, the system initiates precautionary measures, such as activating the water pump or notifying the user.





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#### 4. An Independent Firefighting System:

To target the impacted area, a servo motor changes the water pump nozzle's direction. The water pump draws watefrom a storage tank and sprays it on the flames. The device continues to monitor the fire condition and shuts down the water pump after the fire is extinguished, reducing water waste

#### 5. Navigation via Motor:

Manual Mode: A movement smartphone application integrates with the system via Bluetooth and allows users to control the robot's movement on a general-purpose smartphone. It utilizes HC-05 Bluetooth to send commands to the Arduino Uno, which activates the motor driver module to control the motors.

Autonomous Mode: The system can relocate based on the fire sensor input so that the area of interest is adequately covered for extinguishing fires.

#### 6. User Interaction and Remote Monitoring:

Users can control and monitor the system with the IoT Blynk dashboard that displays all relevant sensor data collected from ESP8266 and alarms. The user is able to view live footage through the ESP32-CAM module, thus evaluating thefire situation from a distance [5]. In scenarios that require it, users can take command of the system interface and set the water pump in motion, or changes its position.

#### 7. Safety Precautions and System Reliability:

The system operates even during power outages using a battery backup. The system performs regular self-checks to verify that the sensors, actuators, and communication modules are functioning properly. If any of the sensors fail, the system alerts the user and provides alternative safety measures. It ensures that fire emergencies are responded to as quickly as possible by integrating wireless communication, autonomous firefighting systems, and real time monitoring. This technique allows for effective hazard mitigation, minimizes damage, and increases safety.

#### **IV. EXPERIMENTAL RESULTS**

The effectiveness of the suggested system in detecting fire and dangerous gases, sending out real-time notifications, and facilitating remote navigation was assessed through successful implementation and testing. The ESP8266, ESP32-CAM, temperature sensor, gas sensor, flame sensor, Arduino Uno, HC-05 Bluetooth module, and motorized navigation system were among the essential parts that went into assembling the hardware configuration. These modules' integration ensured real-time data collecting and reaction mechanisms, enabling the system to operate as planned. To evaluate sensor accuracy and system response time, the hardware module's operation was tested in a variety of scenarios. By correctly detecting the presence of fire and dangerous gasses, the gas sensor and flame sensor activated the fire extinguishing system and sent out real-time alerts, among other automatic activities. The Blynk platform, which offered ongoing monitoring and historical data reporting, received sensor data from the ESP8266. Furthermore, users were successfully alerted via email in the event of an emergency. When a fire or gas was detected, the real-time alert notification system, which was put into place using Blynk, successfully sent out immediate alerts.





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The smartphone app showed notifications, guaranteeing prompt awareness of possible risks. The system responded to every test case with little delay, and the efficacy of these alerts was evaluated in a variety of environmental settings. Using MIT App Inventor, a mobile interface was created for system navigation, giving users control over the robot's direction for improved fire monitoring and suppression. Both Bluetooth and Wi-Fi control modes were available on the interface, guaranteeing flexibility depending on the operational environment. The system's mobility was tested with various directional inputs, and it obeyed user orders with good amount of accuracy.

The system is effective in identifying gas and fire threats, sending out real-time notifications, and enabling remote navigation, according to the testing results taken together. By combining mobile control, automatic response systems, and Internet of Things-based monitoring, the system can effectively aid in fire prevention and mitigation. By monitoring the flame sensor's response over time, its capacity to detect fire was evaluated.



FIGURE 3. Flame Sensor Readings Over Time

As seen in Figure 3, the sensor initially recorded 0 intensity, indicating that there was no fire. The intensity increased gradually until it peaked at 40 seconds after a flame was detected at around 15 seconds. The graph shows how successfully the sensor detects fire, making it eligible for early detection and automatic response systems.

Test scenario	Flame sensor detection time (s)	Alert triggered (Yes/No)	Fire suppression activated (Yes/No)
No Fire Present	-	No	No
Small Fire (Low Flame)	3	Yes	No (Monitoring Only)
Moderate Fire	2	Yes	Yes
Large Fire	1	Yes	Yes





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Under various circumstances, the system's capacity to detect fires was evaluated, with particular attention paid to sensor reaction time, alert activation, motor movement, and fire suppression. The flame sensor identified moderate and big fires in 2 and 1 seconds, respectively, whereas minor fires were detected in 3 seconds, as indicated in Table 1. For all fire incidents, alerts were set off, and for moderate and major fires, suppression was initiated.

#### V. CONCLUSION

The design and implementation of an Internet of Things (IoT)-enabled gas and fire detection system with autonomous firefighting and real-time monitoring was presented in this study. A temperature sensor, ESP8266, ESP32-CAM, a motorized navigation unit, and flame and gas sensors are all effectively integrated into the system to provide effective fire detection and suppression. User responsiveness and accessibility are improved by using MIT App Inventor for remote navigation and Blynk for alerts in real-time. The results of the experiments showed that the system can reliably activate alarms, identify fires quickly, and autonomously move toward dangerous locations for action. The motorized unit allowed for fine movement control, while the flame sensor demonstrated excellent accuracy in detecting fires. By combining remote monitoring with IoT-based alerts, users are guaranteed to receive timely information, enhancing safety and hazard awareness. All things considered, the suggested system lowers the risks related to fire dangers by offering a dependable and autonomous solution on detecting fires along with mitigation. It can be used in households, trades along with manufacturing sectors where safeguarding from fire remains a serious issue, clearly demonstrated by the testing and successful implementation.

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