IoT Enabled Real Time Industrial Environment Monitoring and Workplace Safety System using Raspberry pi

Mr. A. Amareswara Kumar[1], N. Revathi[2], G. Sagarika[3] , T. Navya[4] , D. Yamini[5] , V. Ramya[6]

[1]Assistant professor, Dept., of ECE, ACEM, aamar404.ssits@gmail.com[1]
[2,3,4,5.] student, Dept., of ECE, ACEM, revathinarnavaram@gmail.com[2]

ABSTRACT: The IoT-Enabled Real-Time Industrial Environment Monitoring and Workplace Safety System is designed to enhance industrial safety by continuously monitoring critical environmental parameters and responding to potential hazards. Utilizing a Raspberry Pi as the central controller, the system integrates multiple sensors, including DHT11 for temperature and humidity, MQ135 and MQ2 for air quality and gas detection, fire sensors, vibration and sound sensors, and LDR for light intensity. Sensor data is processed through an ADC module when required, displayed on an LCD, and transmitted to Thing Speak for cloud-based visualization and remote monitoring. By implementing a Random Forest machine learning algorithm, the system analyzes real-time and historical data to detect abnormal patterns, predict potential hazards, and provide intelligent safety recommendations. In response to detected threats, the Raspberry Pi autonomously triggers relays, LEDs, buzzer, CPU fan, and a water pumping motor to mitigate risks, ensuring a safer workplace. This integrated approach demonstrates how IoT, machine learning, and real-time automation can work together to optimize industrial operations, reduce human intervention, and enhance workplace safety.

Keywords: IoT, Industrial Safety, Environmental Monitoring, Machine Learning, Real-Time Automation

INTRODUCTION

The proposed system focuses on enhancing safety and security within industrial and warehouse environments by integrating fire detection with user authentication using Internet of Things (IoT) technology. Utilizing a Raspberry Pi as the central processing unit, the system continuously monitors environmental conditions, including temperature, smoke, and gas levels, to promptly detect potential fire hazards. Upon detecting an abnormal situation, the system triggers real-time alerts to authorized personnel via IoT-enabled notifications, allowing rapid response and minimizing damage.In addition to fire detection, the system incorporates an authentication mechanism to control and monitor access to the workhouse. This ensures that only authorized personnel can enter sensitive areas, improving overall security and operational safety. The combination of real-time monitoring, intelligent alerting, and secure access control makes this system a comprehensive solution for modern industrial safety management.The implementation demonstrates how IoT devices and Raspberry Pi technology can be leveraged to create an efficient, reliable, and scalable safety system suitable for small to medium-sized workhouses, contributing to both fire hazard prevention and access security [1].

This study presents an intelligent system designed for early fire detection and effective mitigation to enhance safety in residential, industrial, and commercial environments. The system integrates advanced sensors capable of detecting smoke, temperature anomalies, and harmful gases, with real-time data processing to identify fire hazards promptly. Upon detection, the system initiates automated mitigation measures, including activating alarms, controlling suppression mechanisms, and notifying relevant personnel through IoT-enabled alerts.The system employs intelligent decision-making algorithms to differentiate between false alarms and actual fire events, reducing unnecessary interventions while ensuring rapid response in critical situations. By combining proactive detection with automated mitigation, the proposed system not only minimizes potential damage but also ensures the safety of occupants and assets. This approach demonstrates how modern intelligent systems can provide reliable, scalable, and efficient solutions for fire safety management across various environments [2].

This paper presents a Fire Monitoring and Control System designed to enhance safety and minimize risks in residential, commercial, and industrial environments. The system utilizes a network of sensors to continuously monitor parameters such as temperature, smoke, and hazardous gas levels. When abnormal conditions are detected, the system provides real-time alerts to concerned personnel through IoT-enabled notifications, ensuring a rapid response to potential fire hazards.In addition to monitoring, the system incorporates automated control mechanisms that can activate alarms, trigger fire suppression systems, and manage safety protocols to contain and mitigate fire incidents. By integrating continuous monitoring with intelligent control measures, the system reduces potential property damage and ensures the safety of occupants. The proposed approach demonstrates how modern IoT technologies can be effectively employed to provide a reliable, scalable, and efficient solution for proactive fire management [3].

This study proposes a smart environmental monitoring system leveraging the Internet of Things (IoT) and Raspberry Pi to provide real-time insights into environmental conditions. The system employs multiple sensors to measure key parameters such as temperature, humidity, air quality, and gas concentrations. Data collected by the sensors is processed by the Raspberry Pi and transmitted via IoT protocols to a centralized platform for analysis and visualization.The system enables continuous monitoring, early detection of environmental anomalies, and automated alerts, supporting proactive decision-making for maintaining safe and healthy environments. Its scalability and adaptability make it suitable for applications in industrial sites, smart buildings, and urban areas. By integrating IoT technology with real-time data processing, the proposed approach offers an efficient, reliable, and cost-effective solution for comprehensive environmental monitoring and management [4].

This paper presents an IoT-enabled Air Quality Monitoring System (AQMS) designed to continuously monitor and assess environmental air quality in real-time. Using a Raspberry Pi as the central processing unit, the system integrates sensors capable of detecting pollutants such as carbon monoxide (CO), carbon dioxide (CO_2), particulate matter (PM2.5/PM10), and other hazardous gases. The collected data is processed locally and transmitted via IoT protocols to cloud-based platforms, enabling remote monitoring, analysis, and visualization.The system provides automated alerts when pollutant levels exceed predefined safety thresholds, supporting timely intervention and decision-making to protect public health. Its scalable design makes it suitable for urban areas, industrial zones, and smart city applications. By combining IoT technology with real-time sensor data, this AQMS offers a cost-effective, reliable, and efficient solution for proactive air quality management [5].

RELATED WORKS

This study proposes a Raspberry Pi-based system for real-time monitoring of industrial processes using wireless communication technologies. The system integrates various sensors to measure critical parameters such as temperature, pressure, humidity, and operational status of machinery. The collected data is processed by the Raspberry Pi and transmitted over wireless networks to a centralized platform, enabling remote access and continuous monitoring from any location worldwide.By providing real-time alerts and detailed analytics, the system helps in early detection of faults, process inefficiencies, and safety hazards, allowing for timely intervention and maintenance. Its scalable and adaptable design makes it suitable for diverse industrial applications. The integration of Raspberry Pi and wireless communication demonstrates an efficient, reliable, and cost-effective solution for global industrial process monitoring [6].

This paper presents a comprehensive survey on the adoption and impact of the Internet of Things (IoT) within the industrial sector. The study examines the current trends, applications, and challenges associated with IoT deployment in industries such as manufacturing, logistics, energy, and smart infrastructure. By analyzing market reports, case studies, and recent research, the survey highlights how IoT technologies—including sensors, cloud computing, and wireless communication—are transforming industrial operations, improving efficiency, reducing operational costs, and enabling predictive maintenance.The paper also identifies key barriers to IoT adoption, such as security concerns, interoperability issues, and high implementation costs, and discusses strategies for overcoming them. This survey provides valuable insights for industry stakeholders, researchers, and policymakers seeking to understand the evolving role of IoT in shaping the future of industrial processes [7].

This paper explores the transformative role of the Internet of Things (IoT) in modern industrial environments. IoT enables the seamless integration of sensors, devices, and machines to collect, process, and exchange data in real-time, thereby enhancing operational efficiency, productivity, and safety. The study highlights key industrial applications of IoT, including predictive maintenance, process automation, supply chain optimization, and remote monitoring of equipment and environmental conditions.Additionally, the paper addresses the challenges associated with IoT adoption in industries, such as data security, interoperability, and infrastructure requirements. By analyzing current trends and technological developments, the study demonstrates how IoT can drive smart manufacturing and intelligent industrial processes, offering scalable and cost-effective solutions that improve decision-making, reduce downtime, and support sustainable industrial growth [8].

This paper presents an in-depth study on industrial automation facilitated by the Internet of Things (IoT). By integrating IoT-enabled sensors, actuators, and smart devices into industrial processes, the system enables real-time monitoring, data collection, and remote control of machinery and production lines. This connectivity allows for enhanced operational efficiency, predictive maintenance, and reduced downtime, leading to significant cost savings and improved productivity.The study also highlights key applications of IoT in automation, including process optimization, energy management, and safety monitoring. Challenges such as data security, interoperability, and network reliability are addressed, along with strategies to overcome them. The research demonstrates that IoT-based industrial automation provides a scalable, flexible, and intelligent solution, paving the way for smarter, more responsive, and sustainable manufacturing environments [9].

This paper presents a system for global industrial process monitoring using Raspberry Pi and wireless communication technologies. The system integrates multiple sensors to measure critical industrial parameters such as temperature, pressure, humidity, and equipment status. The Raspberry Pi processes the collected data and transmits it over wireless networks to a centralized platform, enabling remote monitoring and control from any location worldwide.The proposed approach provides real-time alerts, detailed analytics, and operational insights, which support predictive maintenance, fault detection, and process optimization. Its scalable and flexible design makes it suitable for diverse industrial applications, ranging from manufacturing plants to energy and logistics sectors. By combining Raspberry Pi capabilities with wireless communication, the system offers an efficient, reliable, and cost-effective solution for modern industrial monitoring and management [10].

Recent research has explored IoT-based industrial monitoring systems to improve workplace safety and operational efficiency. Systems using sensors like DHT11 for temperature and humidity, MQ series for gas detection, and vibration or sound sensors have successfully detected hazardous conditions. Cloud platforms such as ThingSpeak enable remote monitoring and historical data analysis, while machine learning algorithms, including Random Forest, help predict potential risks. Some implementations include automated responses, such as alarms, fans, and relays, to mitigate dangers. These studies underline the value of integrating IoT, real-time monitoring, and automation for safer industrial environments [11].

IoT-enabled monitoring solutions have been widely studied to enhance industrial safety. Researchers have combined environmental sensors, including temperature, humidity, gas, and light sensors, with cloud-based platforms for real-time data visualization. Predictive analytics using machine learning further improves risk detection and decision-making. Automated interventions, such as activating alarms, fans, or pumps, have been implemented to respond to threats without human intervention. While previous works demonstrate the benefits of sensor integration and remote monitoring, there is still a need for fully integrated systems that analyze multiple parameters and take proactive actions, motivating the current Raspberry Pi-based approach [12].

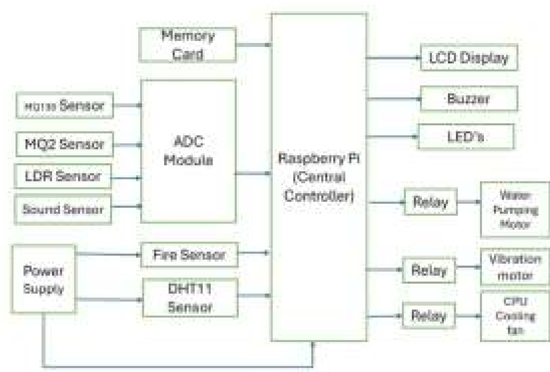
Industrial safety systems leveraging IoT focus on continuous monitoring of environmental and operational parameters. Sensor networks, cloud connectivity, and real-time dashboards allow for early detection of hazardous conditions. Machine learning models, like Random Forest, are applied to identify anomalies and forecast potential risks. Automation mechanisms, including relays, buzzers, and motors, are used to immediately mitigate threats. Prior research confirms the effectiveness of combining sensing, data analytics, and automated responses, but most studies focus on isolated parameters. The current approach integrates multiple sensors and intelligent controls on a Raspberry Pi to create a comprehensive real-time safety system [13].

PROPOSED METHOD

The proposed model presents an IoT-based real-time industrial environment monitoring and safety system aimed at improving workplace safety through continuous surveillance and automated responses. At the core of the system, a Raspberry Pi serves as the central processing unit, managing data acquisition, processing, and actuation tasks. The system integrates a suite of sensors: DHT11 for measuring temperature and humidity, MQ135 and MQ2 for air quality and gas detection, fire detection sensors, vibration and sound sensors, and LDR for monitoring light intensity. Sensor outputs are processed using an ADC module when necessary, displayed locally on an LCD screen, and simultaneously transmitted to ThingSpeak for cloud-based visualization and remote monitoring.To enhance intelligence, the system employs a Random Forest machine learning algorithm, which analyzes both real-time and historical sensor data to detect abnormal patterns, predict potential hazards, and provide actionable safety recommendations. Upon identification of threats, the Raspberry Pi autonomously activates safety mechanisms including relays, LEDs, buzzers, a CPU fan, and a water pumping motor, effectively mitigating risks.

This integrated framework demonstrates the convergence of IoT, machine learning, and real-time automation in creating a proactive industrial safety system. By reducing the reliance on manual supervision and enabling swift automated responses, the proposed model ensures safer and more efficient industrial operations.

Block Diagram:



The block diagram illustrates the architecture of an IoT-enabled industrial safety monitoring system. At the core of the system is a Raspberry Pi, which functions as the central controller responsible for collecting, processing, and responding to sensor data. Multiple sensors are connected to the Raspberry Pi to monitor environmental and operational parameters. These include a DHT11 sensor for temperature and humidity, MQ135 and MQ2 gas sensors for air quality and hazardous gases, a sound sensor, a vibration sensor, a fire sensor, and an LDR sensor for light intensity. Data from analog sensors is interfaced via an ADC module, while storage and logging are managed through a memory card. The system is powered through a dedicated power supply.The processed data triggers various output devices to ensure safety and operational efficiency. These outputs include an LCD display for real-time parameter visualization, a buzzer for alerts, a relay module for controlling external devices, LED indicators, a CPU cooling fan for thermal management, and a water pumping motor for fire suppression or cooling purposes. This integrated design enables continuous monitoring, rapid response to hazards, and enhanced safety in industrial environments.

Methodology
Principle of Functioning

The proposed IoT-Enabled Real-Time Industrial Environment Monitoring and Workplace Safety System is developed to enhance industrial safety through continuous observation and intelligent analysis of environmental parameters. The Raspberry Pi acts as the central processing unit, continuously acquiring data from multiple sensors installed within the industrial environment. These include DHT11 for temperature and humidity measurement, MQ135 and MQ2 for air quality and gas detection, fire sensors for flame identification, vibration and sound sensors for abnormal mechanical activity detection, and an LDR for monitoring light intensity.The collected sensor data is processed in real time, and when necessary, analog signals are converted using an ADC module for accurate digital interpretation. The processed information is displayed locally on an LCD for immediate on-site awareness and simultaneously transmitted to ThingSpeak for cloud-based monitoring and visualization.To enhance decision-making capability, a Random Forest machine learning algorithm is implemented within the system. This algorithm analyzes both real-time and historical data to identify unusual patterns, predict potential hazards, and generate intelligent safety alerts. When abnormal conditions such as gas leakage, excessive temperature, fire detection, or abnormal vibrations are identified, the system automatically activates protective mechanisms. These include triggering relays, LEDs, a buzzer, a cooling fan, and a water pumping motor to mitigate risks and prevent accidents. Through this autonomous operation, the system reduces human intervention while ensuring rapid and reliable response to hazardous situations.

Hardware & Alerts:

The hardware architecture consists of a Raspberry Pi as the central controller, integrated with environmental and safety sensors such as DHT11, MQ135, MQ2, fire sensor, vibration sensor, sound sensor, and LDR. An ADC module is incorporated where analog signal conversion is required. An LCD module provides real-time local display of environmental parameters, while relays control external safety devices including LEDs, buzzer, cooling fan, and water pump motor.For remote monitoring and data visualization, the system is connected to ThingSpeak, enabling supervisory personnel to observe industrial conditions from any location. Intelligent alerts are generated whenever sensor readings exceed predefined safety thresholds or when the machine learning model detects abnormal behavior. The system automatically initiates warning signals and activates mitigation devices without requiring manual intervention, ensuring quick response even in critical situations.

Power Requirements:

The system operates on a regulated 5V power supply to ensure continuous and stable functioning of the Raspberry Pi, sensor modules, ADC unit, LCD display, relay drivers, and communication interfaces. Efficient power management is implemented to support uninterrupted environmental monitoring, real-time cloud updates, and automated safety responses.

By maintaining low power consumption and reliable operation, the system is suitable for long-duration industrial deployment. Continuous power availability ensures consistent data acquisition, intelligent analysis, real-time alerts, and automated hazard control, thereby enhancing overall workplace safety and operational efficiency.

Table 1: Performance *Comparison Table*

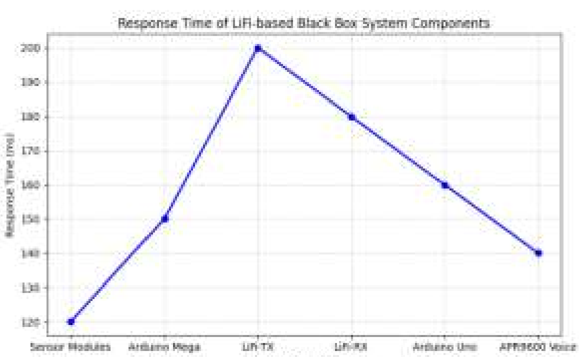
Parameter	**Specification / Metric**	**Description**
Central Controller	Raspberry Pi	Acts as the primary processing and control unit, acquiring sensor data, executing the machine learning algorithm, controlling safety devices, and managing cloud communication.
Environmental Monitoring	DHT11 (Temperature & Humidity)	Continuously monitors ambient temperature and humidity levels to detect overheating or unfavorable environmental conditions.
Gas & Air Quality Detection	MQ135 & MQ2 Gas Sensors	Detects harmful gases, smoke, and air quality variations to identify potential leakage or hazardous atmospheric conditions.
Fire Detection	Flame/Fire Sensor	Identifies the presence of fire or flame within the industrial premises for early hazard detection.
Mechanical Monitoring	Vibration & Sound Sensors	Detects abnormal vibrations or unusual sound patterns indicating machinery faults or unsafe operating conditions.

Light Monitoring	LDR (Light Dependent Resistor)	Measures light intensity to ensure proper illumination and detect abnormal lighting conditions.
Data Processing	ADC Module (if required)	Converts analog sensor outputs into digital signals for accurate processing by the controller.
Cloud Communication	ThingSpeak	Enables real-time data transmission, cloud storage, visualization, and remote monitoring of industrial parameters.

The IoT-based industrial safety system is built around a Raspberry Pi that functions as the central controller for data acquisition, processing, and automation. Multiple sensors, including DHT11, MQ135, MQ2, flame, vibration, sound, and LDR, continuously monitor environmental and mechanical conditions within the industry.Sensor data is processed (using ADC where required), displayed locally on an LCD, and transmitted to ThingSpeak for remote monitoring and cloud-based visualization. A Random Forest algorithm analyzes real-time and historical data to detect abnormal patterns and predict potential hazards.

When unsafe conditions are identified, the system automatically activates relays, LEDs, buzzer, cooling fan, and water pump motor to provide alerts and mitigate risks. Powered by a regulated 5V DC supply, the system ensures continuous monitoring, intelligent decision-making, and rapid automated response, thereby enhancing overall workplace safety and operational efficiency.

Reaction time of the system components



Graph 1: *Reaction time of system components*

X-axis: Hardware Modules
Y-axis: Response Time (s)

Table 1: Comparative Analysis of Conventional Techniques and the Developed Approach

Parameter	Existing Methods	Proposed Approach (Our System)
Environmental Data Collection	Manual inspection or isolated sensors without centralized processing	Raspberry Pi continuously collects data from DHT11, MQ135, MQ2, flame, vibration, sound, and LDR sensors for integrated monitoring
Monitoring Mechanism	Periodic checking and human supervision	Continuous real-time monitoring with automatic detection of abnormal environmental and mechanical conditions
Data Analysis	Threshold-based alerts or no predictive capability	Random Forest machine learning algorithm analyzes real-time and historical data to detect patterns and predict potential hazards
Alert Generation	Manual alarms or basic warning indicators	Automatic activation of LEDs, buzzer, cooling fan, and water pump motor when unsafe conditions are detected
Remote Monitoring	Limited or no remote access to data	Cloud-based monitoring and visualization through ThingSpeak for real-time supervision
Risk Mitigation	Human intervention required to control hazards	Autonomous control of relays and safety devices to reduce risks without human delay

Conventional industrial safety systems rely mainly on manual inspections, standalone sensors, and simple threshold-based alerts, making them reactive and dependent on human supervision. These methods provide limited data recording and minimal remote monitoring capabilities.In contrast, the proposed system uses a centralized architecture based on the Raspberry Pi to continuously collect and process environmental data from multiple sensors. It integrates a Random Forest machine learning algorithm to analyze real-time and historical data, enabling predictive hazard detection rather than simple threshold-based alerts.With cloud connectivity through ThingSpeak, the system supports remote monitoring and data storage. Automated activation of safety devices such as relays, buzzer, cooling fan, and water pump ensures rapid risk mitigation without human delay. Overall, the proposed approach provides a proactive, intelligent, and reliable industrial safety solution compared to traditional methods.

RESULTS

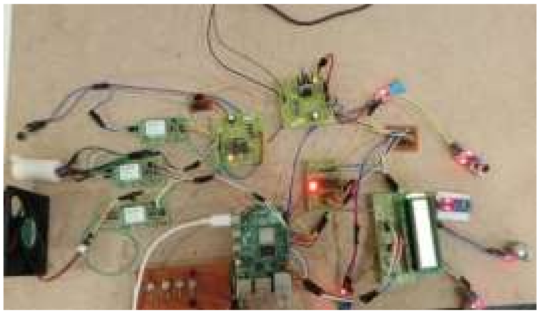


Fig2-*Hardware Kit*

Fig. 2: 2The figure presents the hardware prototype of an IoT-based industrial monitoring and control system. A Raspberry Pi serves as the central controller, interfaced with multiple environmental sensors to measure key parameters. Relay modules enable automated control of connected loads, while a 16×2 LCDs real-time system data. Indicator LEDs provide status alerts, and wireless modules support remote monitoring. The setup demonstrates an integrated and compact design for real-time industrial safety and automation applications.

Fig3-*Real-Time Sensor Data Display on LCD Module*

Fig:3 The figure shows a 16×2 LCD module integrated into the monitoring system, displaying real-time sensor measurements. The screen presents the light intensity value obtained from the LDR sensor along with the overall sound level detected by the sound sensor module. The LCD is interfaced with the main controller through multiple data and control lines, enabling continuous updating of environmental parameters.This visual output confirms proper sensor acquisition and data processing within the system. The displayed readings demonstrate the capability of the prototype to monitor ambient light and acoustic levels simultaneously, supporting real-time environmental analysis and safety assessment applications.

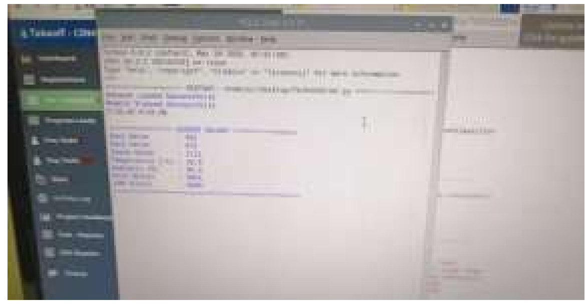


Fig4-*Software Console Output Showing Sensor Data Processing and Model Execution*

Fig:4 The figure presents the software execution window displaying real-time sensor readings and system status after successful initialization of the monitoring program. The console confirms that the trained model has been loaded successfully, indicating proper integration of the machine learning component with the system.

The output section lists measured parameters such as gas levels, temperature, humidity, sound intensity, fire detection status, and LDR status. These values are continuously updated and processed by the program to evaluate environmental conditions. The displayed results demonstrate the correct functioning of data acquisition, processing, and analysis modules within theintegrated monitoring framework.

Fig5-*Cloud-Based Visualization of Industrial Sensor Data*

Fig:5 The figure illustrates the cloud dashboard used for remote monitoring of industrial parameters through the ThingSpeak platform. Multiple field charts are displayed on the screen, each representing a specific environmental parameter collected from the deployed sensing system. The graphical plots show variations in sensor readings over time, enabling continuous tracking and analysis of system performance.

The dashboard provides an organized visualization interface where real-time data uploaded from the IoT device is stored, processed, and presented in graphical form. This cloud integration enables remote supervision, historical data analysis, and performance evaluation of the monitoring system. The implementation demonstrates effective data transmission from the hardware unit to an online platform for scalable and centralized industrial monitoring.

CONCLUSION

The IoT-Enabled Real-Time Industrial Environment Monitoring and Workplace Safety System demonstrates an effective integration of sensing technologies, cloud connectivity, machine learning, and automated control to enhance industrial safety. By utilizing the Raspberry Pi as the central controller, the system continuously monitors critical environmental parameters such as temperature, humidity, gas concentration, fire presence, vibration, sound, and light intensity.The incorporation of a Random Forest algorithm enables intelligent analysis of both real-time and historical data, allowing early detection of abnormal conditions and prediction of potential hazards. Unlike conventional safety mechanisms that rely primarily on manual supervision or fixed threshold alerts, the proposed system offers proactive decision-making and automated response. The integration with ThingSpeak further enhances its capability by providing remote monitoring, data visualization, and long-term storage for safety evaluation.Upon detection of unsafe conditions, the system autonomously activates appropriate mitigation measures such as relays, buzzer alerts, cooling fans, and water pumping mechanisms, thereby minimizing human intervention and response time. Through continuous monitoring, intelligent hazard prediction, and real-time automation, the proposed framework contributes to improved workplace safety, operational efficiency, and reduced risk in industrial environments.

REFERENCES

1. M. Ibrahim, A. Elgamri, and A. Mohamed, “Internet of Things Based Smart Environmental Monitoring Using the Raspberry-Pi Computer,” IEEE, 2015.
2. S. C. and P. I., “IoT Based Industrial Sensor Monitoring and Alerting System Using Raspberry Pi,” IOP Conference Series: Materials Science and Engineering, vol. 981, 2020.
3. S. A. Ali and A. Ali, “Raspberry Pi in Industry 4.0: A Comprehensive Review of Applications in Industrial IoT and Digital Twin Systems,” Preprints.org, Jul. 2025.
4. S. Pawar, M. Kulkarni, V. B. Ambhore, and P. Gawande, “Raspberry Pi 4 for Real-Time IoT Monitoring with Cloud Integration,” International Journal of Innovative Research in Computer and Communication Engineering, vol. 176, 2025.
5. C.-H. Lee, W.-H. Lee, and S.-M. Kim, “Development of IoT-Based Real-Time Fire Detection System Using Raspberry Pi and Fisheye Camera,” Applied Sciences, vol. 13, no. 15, 2023.
6. H. K. Merchant and D. D. Ahire, “Industrial Automation Using IoT with Raspberry Pi,” International Journal of Computer Applications, vol. 168, no. 1, pp. 44-48, Jun. 2017.
7. “Design of an IoT Approach for Security Surveillance System for Industrial Process Monitoring Using Raspberry Pi,” IEEE Conference Publication.
8. Advancing Workplace Safety with IoT-Enabled Industrial Monitoring, IEEE Conference Publication.
9. IoT-Enhanced Workplace Safety for Real-Time Monitoring and Hazard Detection for Occupational Health, IEEE Conference Publication.
10. D. Raposo et al., “Industrial IoT Monitoring: Technologies and Architecture Proposal,” Sensors, vol. 18, no. 10, 2018.
11. Imteaj, T. Rahman, M. K. Hossain, M. S. Alam, and S. Ahmad, “An IoT Based Fire Alarming and Authentication System for Workhouse Using Raspberry Pi 3,” in Proc. IEEE ECCE, 2017.
12. S. Tanwar et al., “An Advanced Internet of Things Based Security Alert System for Smart Home,” in Proc. CITS, 2017.
13. M. I. Mobin et al., “An Intelligent Fire Detection and Mitigation System Safe from Fire (SFF),” Int. J. Computer Applications, vol. 133, no. 6, 2016.

A. H. Malik et al., “Smart City IoT Based Weather Monitoring System,” Int. J. Engineering Science and Computing, 2017.

14. M. C. Balasubramaniyan and D. Manivannan, “IoT Enabled Air Quality Monitoring System (AQMS) Using Raspberry Pi,” Indian Journal of Science and Technology, vol. 9, no. 39, 2016.
15. P. S. Lonare and M. Kolte, “A Raspberry Pi Based Global Industrial Process Monitoring Through Wireless Communication,” Int. J. Advanced Research in Computer & Communication Engineering, vol. 5, no. 9, 2016.
16. H. P. Breivold and K. Sandström, “Internet of Things for Industrial Automation: Challenges and Technical Solutions,” in Proc. IEEE DSDIS, 2015.
17. Perera, C. H. Liu, and M. Chen, “A Survey on Internet of Things From Industrial Market Perspective,” IEEE, 2015.
18. L. D. Xu, W. He, and S. Li, “Internet of Things in Industries: A Survey,” IEEE Trans. Industrial Informatics, 2014.
19. M. Junaid Asif, S. Saqib, R. F. Ahmad, and H. Khan, “Leveraging Wireless Sensor Networks for Real-Time Monitoring and Control of Industrial Environments,” arXiv preprint, Sep. 2025.