Published by :
https://www.ijert.org/
An International Peer-Reviewed Journal

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 04 , April - 2026

Mechatronics Integrated IoT Fire Fighting Robot

Mr. A. Sakthivel, M.E,
Assistant Professor,
Department of Electronics and Communication Engineering.

Kavikannan R,
Department of Electronics and Communication Engineering.

Rajasekar M,
Department of Electronics and Communication Engineering.

Manoj S,
Department of Electronics and Communication Engineering.

Sakthi D,
Department of Electronics and Communication Engineering.

Abstract **- Fire accidents in residential, industrial, and hazardous environments pose serious threats to human life and property. Conventional fire detection systems mainly rely on smoke sensors and manual intervention, leading to delayed response. This paper proposes a Mechatronics Integrated IoT Fire Fighting Robot that uses gas sensors and flame sensors for early fire detection. An ESP32 microcontroller processes sensor data and automatically activates firefighting mechanisms such as a water pump and mist system. The robot navigates toward the fire source and performs targeted suppression. The system also includes GSM-based alert communication and IoT monitoring using the ThingSpeak platform. This reduces human exposure to dangerous environments and ensures faster response. The proposed system provides an efficient, intelligent, and reliable fire safety solution.**

Keywords - Fire Detection, ESP32, Gas Sensor, Flame Sensor, GSM Module, IoT, Fire Suppression, Autonomous Robot

INTRODUCTION

Fire hazards remain a major safety concern in residential buildings, industries, laboratories, and warehouses. Rapid fire spread and delayed detection often result in severe damage to life and property. Traditional fire safety systems mainly rely on smoke detectors and sprinkler systems, which may not provide accurate early detection or targeted suppression. To overcome these limitations, this work proposes a Mechatronics Integrated IoT Fire Fighting Robot. The system integrates gas and flame sensors for early fire detection and uses an ESP32 microcontroller for real-time processing and control. The robot can automatically navigate toward the fire source and perform suppression without human intervention. The integration of IoT monitoring and GSM communication further enhances safety by enabling remote alerts and real-time observation. This approach improves response time and reduces human risk in hazardous environments.

PROPOSED SYSTEM

The proposed system is a Mechatronics Integrated IoT Fire Fighting Robot designed to improve fire safety through early detection and automated response. The system uses gas sensors to detect combustible gases and flame sensors to identify active fire sources. The ESP32 microcontroller processes sensor data and determines the presence and direction of fire. Based on this analysis, the robot navigates toward the fire source using motor-driven wheels. A servo-controlled mechanism ensures accurate targeting of the extinguishing system. The suppression unit includes a water pump and a humidifier-based mist system to control fire and reduce smoke. A GSM module sends alert messages to users, while IoT connectivity through the ThingSpeak platform enables remote monitoring. This integrated system ensures faster response, reduced human intervention, and efficient fire suppression.

SYSTEM ARCHITECTURE AND BLOCK DIAGRAM

The system architecture consists of sensing, processing, navigation, suppression, and communication modules. Gas and flame sensors continuously monitor environmental conditions and send data to the ESP32 controller. The controller analyzes the data and makes decisions for movement and suppression. Motor drivers control robotic navigation, while relay modules operate the pump and mist system. The GSM module and buzzer provide alerts, and IoT connectivity enables remote monitoring. This structured architecture ensures efficient coordination between all modules for reliable fire detection and suppression.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 04 , April - 2026

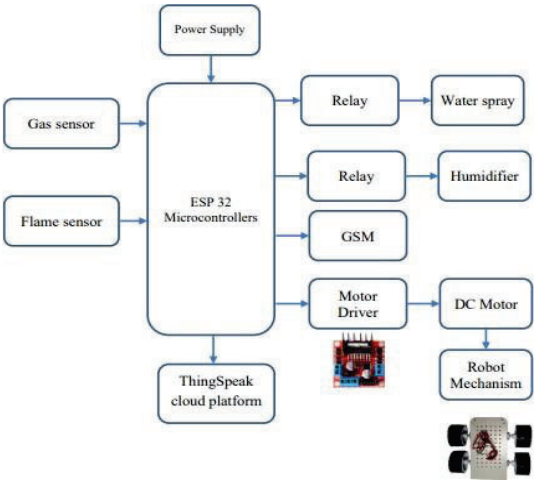

Figure 1. Block Diagram

METHODOLOGY

The methodology of the proposed Mechatronics Integrated IoT Fire Fighting Robot is designed to ensure accurate fire detection, intelligent decision-making, and efficient suppression. Initially, gas sensors and flame sensors continuously monitor environmental conditions to detect combustible gases and fire at an early stage. The sensor data is transmitted to the ESP32 microcontroller, which processes the input signals and compares them with predefined threshold values to confirm the presence of fire. Once fire is detected, the controller determines the appropriate response and activates the navigation system, allowing the robot to move toward the fire source using motor-driven wheels. At the same time, the suppression mechanism, consisting of a water pump and mist system, is activated through relay modules to extinguish the fire effectively. A servo mechanism ensures accurate direction of the spray toward the flame. Additionally, a GSM module sends alert messages to users, and a buzzer provides immediate local warning. The system also supports IoT-based monitoring by transmitting data to the ThingSpeak platform for remote observation. This integrated process ensures fast detection, automated response, reduced human intervention, and improved fire safety.

HARDWARE IMPLEMENTATION

The hardware implementation of the Mechatronics Integrated IoT Fire Fighting Robot is designed to ensure reliable fire detection, autonomous mobility, and efficient suppression in hazardous environments. The system follows an embedded control architecture where sensing, processing, and actuation modules are integrated around the ESP32 microcontroller for real-time decision-making. Gas and flame sensors continuously monitor environmental conditions, while motor drivers control robotic navigation toward the fire source. Relay modules safely operate high-power components such as the water pump and gas spray mechanism. Additionally, the GSM module and buzzer provide remote and local alerts, ensuring fast response and enhanced operational safety.

A. ESP32 microcontroller

Figure 2. ESP32 microcontroller

The ESP32 microcontroller acts as the main control unit of the system. It collects data from the gas and flame sensors, processes the information, and controls the robot's movement and fire suppression mechanisms. It also manages the relay modules and GSM communication for alerts. Its fast-processing speed and multiple input/output pins make it suitable for real-time monitoring and control applications.

B. Gas Sensor

The gas sensor is used to detect the presence of combustible gases in the environment at an early stage. It continuously monitors gas concentration levels and sends the data to the ESP32 microcontroller for analysis. When the gas level exceeds the predefined threshold, it helps in identifying potential fire hazards and triggers necessary preventive actions.

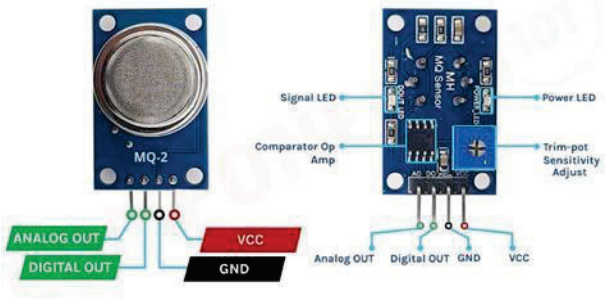

Figure 3. Gas Sensor

C. Flame Sensor

The flame sensor is used to detect the presence of fire by sensing infrared radiation emitted by flames.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 04 , April - 2026

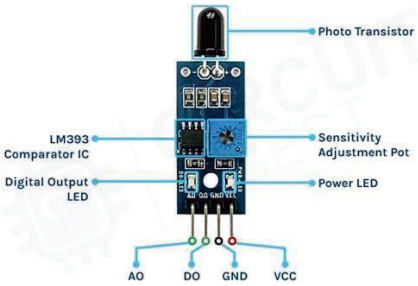

Figure 4. Flame Sensor

It continuously monitors the surroundings and sends signals to the ESP32 when a flame is detected. This enables quick confirmation of fire and allows the system to activate the appropriate suppression mechanism immediately.

D. Relay

Figure 5. Relay

The relay module is used to control high-power devices such as the water pump and gas spray mechanism. It acts as an electrically operated switch, allowing the ESP32 microcontroller to safely turn these components ON or OFF. This ensures proper isolation between low-power control circuits and high-power suppression systems.

E. Pump Motor

The pump motor is used to spray water or fire-suppressing liquid to extinguish the detected fire. It is activated through the relay module when the ESP32 confirms the presence of fire. The pump ensures controlled and efficient delivery of the extinguishing agent toward the fire source, helping to suppress flames quickly and effectively.

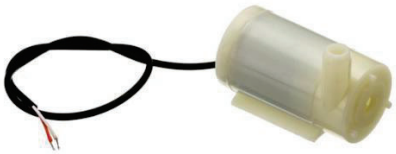

Figure 6. Pump Motor

F. L298N Motor Driver Module

Figure 7. L298N Motor Driver Module

The L298N Motor Driver Module controls DC geared motors for rover locomotion. The driver allows bidirectional motor control and speed adjustment through PWM signals.

G. GSM Module

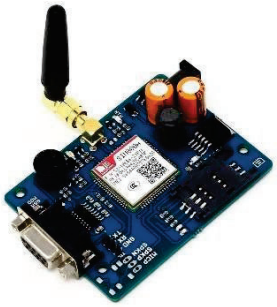

Figure 8. GSM Module

The GSM module is used to provide remote communication during emergency situations. When fire is detected, the ESP32 microcontroller triggers the GSM module to send alert messages to predefined mobile numbers. This ensures immediate notification to responsible authorities or users, enabling quick response and enhanced safety.

SOFTWARE IMPLEMENTATION

The software is developed using Embedded C in the Arduino IDE for the ESP32. It continuously reads sensor data and compares it with predefined thresholds.

When fire is detected, the controller activates motors for navigation and triggers the relay to operate the pump. GSM communication is implemented using AT commands to send alerts. The system ensures fast and reliable operation using proper control logic.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 04 , April - 2026

RESULTS AND DISCUSSION

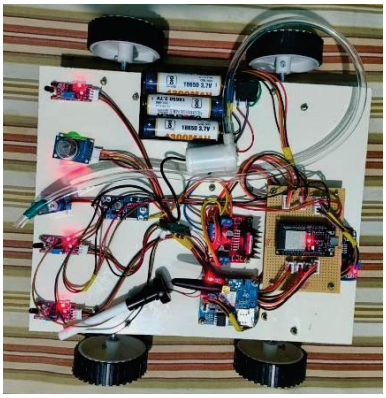

Figure 9. Prototype of Mechatronics Integrated IoT Fire Fighting Robot

The system was tested under different fire and gas conditions. The gas sensor detected leakage at early stages, and the flame sensor confirmed fire presence quickly.

The robot successfully navigated toward the fire source and activated the suppression system. GSM alerts were sent instantly, ensuring remote awareness. The system showed reduced response time and improved safety compared to traditional methods.

FUTURE WORK

Future improvements include integration of AI-based fire detection, thermal imaging cameras, and advanced navigation using obstacle avoidance and SLAM. IoT dashboards and mobile applications can enhance remote monitoring and control.

CONCLUSION

The proposed Mechatronics Integrated IoT Fire Fighting Robot provides an efficient solution for fire detection and suppression. The system reduces human risk, improves response time, and enhances safety using automation and IoT technologies. It is suitable for residential, industrial, and hazardous environments.

REFERENCES

[1] Aarav Singhal, Saumy Singh, Siddharth Siddharth, Vasanthadev Suryakala S, T. Rajalakshmi. “Autonomous Fire Fighting Robotic Vehicle.” *2025 11th International Conference on Communication and Signal Processing (ICCSP)*, 2025.

[2] G. L. V. N. Sridhar, M. Janakiram, M. V. R. Sai, G. S. N. Reddy, M. Belwal. “Smart Water Ball Launcher: An Arduino-Based Fire Extinguishing System.” *2025 3rd International Conference on Intelligent Data Communication Technologies and Internet of Things (IDCIoT)*, Bengaluru, India, 2025.

[3] K. Iyer, S. Jadhav, S. Jadhav, S. Jadhav, V. Jadhav, A. Suryawanshi. “Fire Fighting Robot Using Arduino UNO.” *2024 9th International Conference on Communication and Electronics Systems (ICCES)*, Coimbatore, India, 2024.

[4] K. Arora, H. Kumar, R. R. Singh. “Autonomous Fire Fighting Robot.” *2023 International Conference on Computational Intelligence, Communication Technology and Networking (CICTN)*, Ghaziabad, India, 2023.

[5] L. Zhang, L. Jiang, Y. Wang, K. Li, W. Ding. “The Design of Firefighting Robot Based on the Fuzzy PID Algorithm.” *2024 9th International Conference on Electronic Technology and Information Science (ICETIS)*, Hangzhou, China, 2024.

[6] Mehedi Hasan, Rafiul Islam Sonet, Apu Sen, Ritu Parna Das, Joel Ahmed. “Design and Development of a Fire Fighting Mobile Surveillance Robot with Autonomous Collision Avoidance.” *2021 International Conference on Automation, Control and Mechatronics for Industry 4.0 (ACMI)*, 2021.

[7] Qi Liu, Ye Zhang, Ying Wang, Baohua Li, Yao Gou, Jiaojiao Xu, Deqing Sheng, Zhuang Liu. “Research on Key Technologies of Intelligent Fire Fighting Robot Based on ZigBee Network.” *2020 International Conference on Artificial Intelligence and Computer Engineering (ICAICE)*, 2020.

[8] Junyu Lin, Hongzheng Li, Honglin Huang, Zhida He, Chuntao Zheng, Tianxin Luan. “Intelligent Firefighting Robot Based on HT32F52352.” *2024 7th International Conference on Mechatronics and Computer Technology Engineering (MCTE)*, 2024.

[9] Mehedi Hasan, Rafiul Islam Sonet, Apu Sen, Ritu Parna Das, Joel Ahmed. “Design and Development of a Fire Fighting Mobile Surveillance Robot with Autonomous Collision Avoidance.” *2021 International Conference on Automation, Control and Mechatronics for Industry 4.0 (ACMI)*, 2021.

[10] Remotely Controlled Firefighting Robot with ESP32-CAM Module. “Remotely Controlled Firefighting Robot with ESP32-CAM Module.” 2024.