International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
ISSN: 3068-272X
www.ijdim.com
Original Research Paper

Comprehensive multi hazard railway safety monitoring system using IOT

[1]Shaik Nafrin, [2]Shaik Sameera, [3]Shaik Asreen Bhanu, [4]Purohith Kiran,[5]N. Syamala

[1,2,3,4]U. G Student, Dept ELECTRONICS AND COMMUNICATION ENGINEERING,

St. Ann's College of Engineering and Technology, (Autonomous)Chirala, Bapatla Dist,

Andhra Pradesh – 523187, India

[5]Assistant Professor, Dept ELECTRONICS AND COMMUNICATION ENGINEERING,
St. Ann's College of Engineering and Technology (Autonomous), Chirala, Bapatla Dist,
Andhra Pradesh – 523187, India

ABSTRACT

Railway transportation plays a crucial role in global logistics and public transportation by enabling the movement of passengers and goods efficiently. However, railway safety remains a major challenge due to accidents caused by track faults, fire hazards, gas leakage, physical obstacles, environmental conditions, and human errors. Conventional railway monitoring and inspection methods mainly rely on manual supervision and periodic inspections, which are time-consuming, less efficient, and unable to provide real-time hazard detection. To address these limitations, this project presents an Internet of Things (IoT)-based Railway Safety and Accident Prevention System for continuous and automated monitoring of railway environments. The proposed system integrates multiple sensors with a Raspberry Pi that acts as the central control and processing unit. A fire sensor and MQ-2 gas sensor are used to detect fire and hazardous gas leakage, while IR and ultrasonic sensors identify track faults and obstacles present on the railway path. The Raspberry Pi continuously collects and processes sensor data and initiates immediate actions whenever abnormal conditions are detected. A buzzer generates warning alerts, a motor controls prototype movement, and an LCD displays real-time status information. The integrated Wi-Fi module supports communication and remote monitoring.

KEYWORDS: ***Raspberry pi, Sensor integrating, MQ-2 gas sensor, Integrated Wi-Fi module, Data acquisition, anomaly detection.***

INTRODUCTION

Railway transportation plays a significant role in the movement of passengers and goods, making safety a critical concern in modern transportation systems. Railway networks are exposed to various hazards such as track defects, obstacles, fire incidents, gas leakage, equipment failures, and environmental conditions that can lead to serious accidents and operational disruptions. Traditional monitoring methods are often manual and unable to provide continuous real-time supervision. To overcome these limitations, an IoT-based Comprehensive Multi-Hazard Railway Safety Monitoring System is proposed. The system integrates sensors, Raspberry Pi, and wireless communication technologies to continuously monitor hazardous conditions, detect abnormalities, generate alerts, and improve railway safety, reliability, and operational efficiency.

RELATED WORK

Several studies have focused on improving railway safety using IoT and sensor-based technologies. Researchers developed smart railway monitoring systems using sensors for obstacle detection, track crack identification, and environmental monitoring. IoT-based approaches enable real-time data collection and remote monitoring, improving operational efficiency and reducing accident risks. Some systems integrate gas sensors, fire sensors, and ultrasonic sensors to detect hazardous conditions and generate instant alerts. Other studies emphasize Raspberry Pi-based intelligent platforms for faster processing and communication. These works demonstrate that combining embedded systems, wireless communication, and automation significantly improves railway safety, reliability, and hazard management.

LITERATURE REVIEW

Several research works have been carried out to improve railway safety through IoT and sensor-based technologies. Existing studies focus on applications such as obstacle detection, track crack identification, fire and gas hazard monitoring, and automated alert systems. Researchers have used sensors including ultrasonic, IR, vibration, and gas sensors integrated with Arduino, ESP8266, and Raspberry Pi platforms for real-time monitoring and communication. Advanced techniques such as image processing, cloud connectivity, and machine learning have also been applied for predictive maintenance and anomaly detection. These studies demonstrate that IoT-based monitoring systems significantly improve railway safety, reduce manual inspection efforts, and enhance operational reliability.

International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
ISSN: 3068-272X
www.ijdim.com
Original Research Paper

EXISTING METHOD

The existing railway safety monitoring methods mainly rely on manual inspection, conventional signaling systems, and standalone safety mechanisms for hazard detection. Railway personnel periodically inspect tracks, bridges, and infrastructure to identify defects, while basic sensors and alarm systems are used to detect specific issues such as track cracks or train movement. Some systems use Automatic Train Protection (ATP) and communication technologies for limited monitoring and control. However, these approaches suffer from delayed response, high labor dependency, lack of real-time monitoring, limited hazard detection capability, and difficulty in handling multiple threats simultaneously, reducing overall operational efficiency and safety performance.

PROPOSED METHOD

The proposed system introduces an IoT-based multi-hazard railway safety monitoring solution that provides continuous and real-time monitoring of railway environments. It integrates sensors such as MQ-2 gas sensors, fire sensors, IR sensors, and ultrasonic sensors with a Raspberry Pi controller for detecting gas leakage, fire hazards, obstacles, and track abnormalities.

Sensor data is processed and transmitted through Wi-Fi to enable remote monitoring and alert generation. When abnormal conditions are detected, the system activates a buzzer and displays warnings on an LCD. This approach improves safety, minimizes human intervention, enhances reliability, and supports preventive maintenance strategies.

SYSTEM ARCHITECTURE

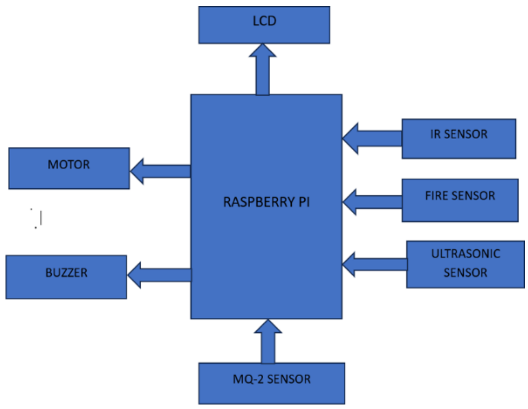

Fig 1: Block Diagram

METHODOLOGY DESCRIPTION

Raspberry Pi Processing Unit

The Raspberry Pi acts as the central controller of the railway safety monitoring system and manages all sensing, processing, and decision-making operations.

Hazard Detection Using MQ-2 and Fire Sensors

The MQ-2 sensor continuously detects the presence of harmful gases or smoke, while the fire sensor monitors flame occurrences in the railway environment. These sensors help identify hazardous situations at an early stage and improve safety measures.

Track and Obstacle Detection Using IR and Ultrasonic Sensors

The IR sensor is used to identify track faults and detect interruptions on railway paths. The ultrasonic sensor continuously measures the distance of nearby objects and detects obstacles to prevent collision risks.

Alert and Notification Mechanism

When hazardous conditions are identified, the buzzer is activated immediately to provide an audible warning signal. This ensures rapid awareness of dangerous situations and supports quick preventive actions.

Display and Motion Control Section

The LCD displays real-time information such as sensor status, warning messages, and detected hazards for easy monitoring. The motor operation is controlled automatically based on sensor outputs to simulate train movement and stopping during unsafe conditions.

SOFTWARE AND HARDWARE REQUIREMENTS

Hardware Requirements

Raspberry Pi

Fig 2: Raspberry Pi

The Raspberry Pi serves as the central processing unit of the system and controls all sensor and output operations. It processes sensor data, makes decisions, and manages communication between different components.

MQ-2 Gas Sensor

Fig 3: MQ-2 Gas Sensor

The MQ-2 sensor is used to detect smoke and harmful gases present in the railway environment. It provides early detection of hazardous gas leakage to improve railway safety.

IR Sensor

International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
ISSN: 3068-272X www.ijdim.com Original Research Paper

Fig 4: IR Sensor

The IR sensor is used for detecting track faults and interruptions on railway tracks. It helps in identifying abnormal conditions and preventing possible accidents.

Fire Sensor

Fig 5: Fire Sensor

The fire sensor detects the presence of flames and fire-related hazards in railway environments. It generates immediate signals when fire is detected for quick response.

Ultrasonic Sensor

Fig 6: Ultrasonic Sensor

The ultrasonic sensor measures the distance between objects and identifies obstacles on the railway track. It helps prevent collisions by detecting nearby objects in real time.

LCD Display

Fig 7: LCD Display

The LCD is used to display sensor readings and warning messages in real time. It provides a user-friendly interface for monitoring system conditions.

Buzzer

Fig 8: Buzzer

The buzzer acts as an alert mechanism and produces an audible warning during hazardous situations. It helps notify operators about emergency conditions immediately.

DC Motor

Fig 9: DC Motor

International Journal of
DATA SCIENCE AND IOT MANAGEMENT SYSTEM
ISSN: 3068-272X www.ijdim.com Original Research Paper

The DC motor is used to simulate train movement in the prototype system. Its operation can be controlled automatically based on hazard detection results.

Power Supply Unit

The power supply provides the required voltage and current to operate all hardware components efficiently. It ensures stable and uninterrupted system performance.

Software Requirements

The software section includes Raspberry Pi OS and Python programming language for developing the monitoring and control system. Python libraries are used for sensor interfacing, data processing, and device control operations. The software also supports Wi-Fi communication, real-time monitoring, and alert

RESULTS AND DISCUSSION

The result of fire detection in modern railway safety systems is a multi-stage response that prioritizes very early warning and automated intervention to prevent casualties and asset loss.The result of fire detection in modern railway safety systems is a multi-stage response that prioritizes very early warning and automated intervention to prevent casualties and asset loss.

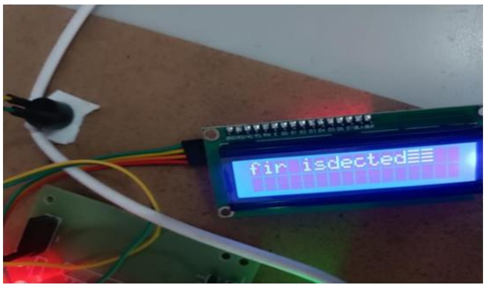

Fig 10: Fire Detection Output Display on LCD

For hazard detection, the system yields a precise, multi-stage result that removes human error from emergency situations. High-sensitivity aspirating smoke detectors can identify invisible particles within 60 to 90 seconds, while AI-driven vision systems detect track obstacles with over 96% accuracy. When a critical hazard—whether smoke or a physical obstruction—is confirmed, the monitoring system automatically triggers a drop in brake pipe pressure to halt the train and simultaneously transmits real-time coordinates to control centers. This integrated response ensures that potential disasters are neutralized before they can escalate into major accidents.

Fig 11: Smoke Detection Output Display on LCD

Fig 12: Object Not Detected Display on LCD

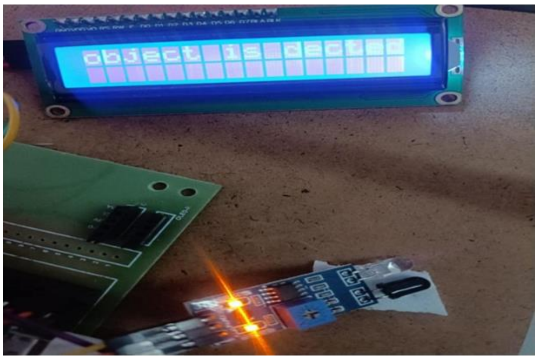

Fig 13: LCD Display Output (Testing/Initialization)

The final result of implementing advanced railway safety monitoring systems is a near-90% red recorded only 16 consequential train accidents in the 2025–26 fiscal year, down from 135 in 2uction in major train accidents over the past decade. As of early 2026, Indian Railways014–15. This transformation is the direct outcome of transitioning from manual inspections to automated, AI- driven monitoring and collision avoidance frameworks.

CONCLUSION

The IoT-based Multi-Hazard Railway Safety Monitoring System effectively enhances railway safety by continuously monitoring critical conditions such as track faults, obstacles, fire hazards, and environmental changes. It enables real-time data collection and instant alerts, reducing dependence on manual inspection and minimizing accident risks. Overall, the system improves reliability, safety, and efficiency in railway operations.

FUTURE SCOPE

In the future, the system can be enhanced using artificial intelligence and machine learning for predictive hazard detection and preventive maintenance. Advanced communication technologies like 5G, NB-IoT, and edge computing can improve speed, reliability, and real-time response.

Additionally, integration of drones, computer vision, and renewable energy sources can make the system more intelligent, autonomous, and sustainable.

REFERENCES

1. Bhavya V., Swetha P., Senthil Kumar S. (2025). Smart Track Continuous Monitoring and Train Collision Avoidance System using IoT. IJRASET Journal for Research in Applied Science and Engineering Technology. DOI: 10.22214/ijraset.2025.68452.
2. Srinivas Babu P., Chandana S H., Namitha G H., Navya K. (2025). Integrated Intelligent Railway Safety System: Fire Detection and Collision Avoidance using IoT. IJARCCE. DOI: 10.17148/IJARCCE.2025.141198.
3. Dileep Kumar Y., Lohitha Y., Teja E., Venkata Kiran G., Manjunath K., VijayKumar M. (2025). Smart Railway Safety System using IoT and Sensor Integration. ICITSM Proceedings. DOI: 10.4108/eai.28-4-2025.2357938.
4. Sakthivel V., Naveen V S., Pavithra S., Rajkumar P., Rubika N. (2025). Advanced IoT Solution for Early Detection of Railway Hazards. IJRASET Journal for Research in Applied Science and Engineering Technology.
5. Ashwini G V., Manasa M., Ramya K., Ashoka S. (2018). A Railway Locomotive Monitoring System using IoT. International Journal of Scientific Research in Computer Science, Engineering and IT.
6. An End-to-End Approach to Detect Railway Track Defects (2024). ScienceDirect Study using YOLOv8 and U-Net for rail defect detection.
7. A LiDAR-Based Obstacle Detection Framework (2024). EPJ Web of Conferences. Long-range LiDAR-based railway obstacle detection system.
8. Recent Advances and Innovative Approaches to Railway Safety (2025). IEEE Xplore Review on modern railway safety systems and standards (EN 50126).
9. DeepRail Scan: Railway Track Defect Detection (2026). YOLOv8s-based drone vision system for railway monitoring.
10. Atzori L., Iera A., Morabito G. (2010). The Internet of Things: A Survey. Computer Networks, 54(15), 2787–2805.
11. Liu Q., Cui L., Chen H. (2010). Key Technologies and Applications of Internet of Things. Computer Science, 37(6), 1–5.

12. Pujolle G. (2006). An autonomic-oriented architecture for the Internet of Things. IEEE Symposium on Modern Computing.
13. Wei Pingping (2012). Cloud-based Internet of Things architecture. Science and Technology Communication, 184, 183.
14. Hemalatha K N et al. IoT-Based Monitoring Systems in Embedded Applications. Dr. Ambedkar Institute of Technology, Bengaluru.
15. Cathrin Deboral C et al. AI and IoT Applications in Smart Systems. Sri Sairam Engineering College, Chennai.