



Integrated Intelligent Railway Safety System: Fire Detection and Collision Avoidance Using IOT

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Abstract: This project aims to develop an integrated intelligent safety system for railways that can detect fire hazards and prevent train collisions using modern technologies like LabVIEW and IoT. The system uses temperature and smoke sensors connected to LabVIEW for real-time fire detection and alert generation.

Simultaneously, an IoT-based collision avoidance module employs ultrasonic and GPS sensors to detect nearby trains or obstacles and transmit warnings to a central control unit. By combining both systems, the project enhances railway safety, automation, and accident prevention, reducing human error and ensuring quicker responses to emergencies.

Keywords: Collision avoidance, Internet of things (IoT), Automation, Real-Time Monitoring, Temperature Sensor, GPS Module, Ultrasonic Sensor, Smoke Sensor, Alert System, Smart railway, Accident Prevention, LABVIEW

I. INTRODUCTION

The integrated intelligent railway safety system is a comprehensive solution designed to enhance the safety and efficiency of railway operations by incorporating advanced technologies such as LabVIEW and IoT.

This system focuses on two critical aspects such as sprinkler systems or alarm of railway safety: fire detection and collision avoidance. Fire detection is implemented LabVIEW, which provides a robust platform for real-time monitoring and data acquisition from various onboard sensors, ensuring early detection and rapid response to fire hazards.

This project, “Integrated Intelligent Railway Safety System,” aims to develop a smart solution that ensures passenger and train safety by combining fire detection and collision avoidance mechanisms. The system integrates Arduino UNO, IR sensors, fire sensors, and Zigbee modules with LabVIEW software for data monitoring and control. The fire detection unit senses smoke or flame inside the train and sends an alert to the control station, while the collision avoidance system continuously tracks train positions to prevent accidents. This project proposes an Integrated Intelligent Railway Safety System that leverages IoT and LabVIEW technologies to enhance railway safety. The system integrates fire detection and collision avoidance features, providing real-time monitoring and alerts to prevent accidents. By utilizing IoT sensors and LabVIEW-based data analysis, the system aims to reduce the risk of fire-related accidents and collisions, improve response times, and protect human life and infrastructure. The expected outcome is a safer and more efficient railway system. The system uses LabVIEW for fire detection and IoT technology for collision avoidance, ensuring real-time monitoring and rapid response. By integrating these technologies, the system provides a robust safety framework, reducing risks and improving passenger safety.

II. METHODOLOGY

The proposed Integrated Intelligent Railway Safety System utilizes IoT sensors and devices to detect potential fire hazards and prevent train collisions. The proposed system is developed through an integrated approach that combines fire detection using LabVIEW, linear-track monitoring, and collision avoidance using IoT to create a unified railway safety platform. The methodology begins with the data acquisition stage, where various sensors are deployed on the train and trackside to continuously monitor safety parameters.

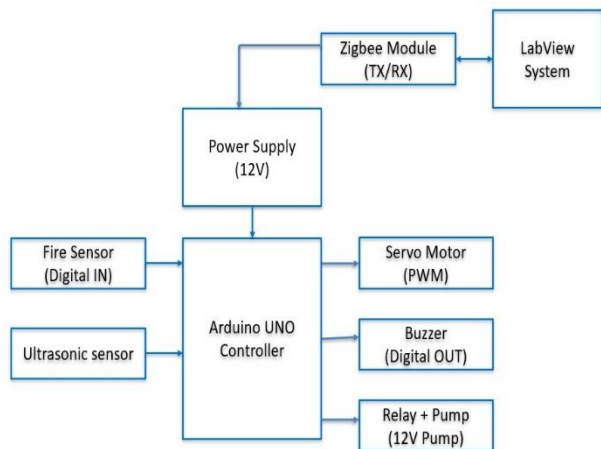


Fig. 1 Train A & B block Diagram

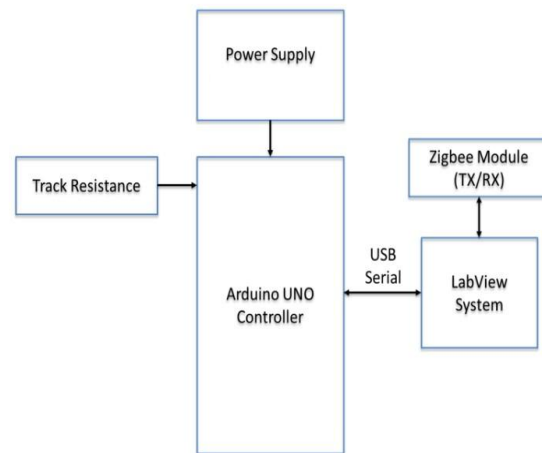


Fig 2: Train Station Block Diagram

The proposed system consists of two major units, Train- A and Train-B, each built around an Arduino UNO controller for ensuring railway safety. In Train-A, the Arduino UNO receives a regulated 12V supply which powers all the connected components. A fire sensor and an ultrasonic sensor are interfaced as input modules to continuously monitor fire occurrence and detect obstacles or train presence on curved tracks. Based on these sensor readings, the controller activates various output actuators such as a servo motor for mechanical control, a buzzer for audible alerts, and a relay-driven 12V water pump for automatic fire extinguishing. A ZigBee wireless module is connected to the controller for transmitting real-time data to the LabVIEW monitoring system, enabling remote supervision and timely alerts.

Train-B also uses an Arduino UNO controller powered by a 12V supply. Here, a track-resistance sensor is interfaced to detect abnormal resistance variations on the railway track, which indicate obstruction, track fault, or the presence of another train. The processed data is communicated to the LabVIEW system through both USB serial communication and a ZigBee module, ensuring reliable and continuous monitoring. The LabVIEW interface displays live data from both trains, allowing immediate analysis and safety decision-making. Overall, the block diagram demonstrates an integrated fire detection and collision avoidance system using sensors, wireless communication, and real-time monitoring.

The block diagram illustrates the working of the collision detection and monitoring unit based on track resistance. The system is built around an Arduino UNO controller, which serves as the central processing unit. A regulated power supply provides the required operating voltage to the Arduino and its interfaced modules. The track resistance sensor is connected to the Arduino as the primary input, continuously monitoring the electrical resistance of the railway track. Any change in resistance indicates the presence of an obstacle, another train, or a possible track fault. The Arduino processes these readings and sends the data to the monitoring unit through two communication channels. One channel uses

a USB serial connection directly from the Arduino to the LabVIEW system for real-time wired data transfer.

The second communication path uses a ZigBee (TX/RX) wireless module, which transmits sensed data to the LabVIEW interface for remote monitoring and alert generation. The LabVIEW system displays and logs the received information, enabling effective detection of track abnormalities and enhancing railway safety.

III. IMPLEMENTATION

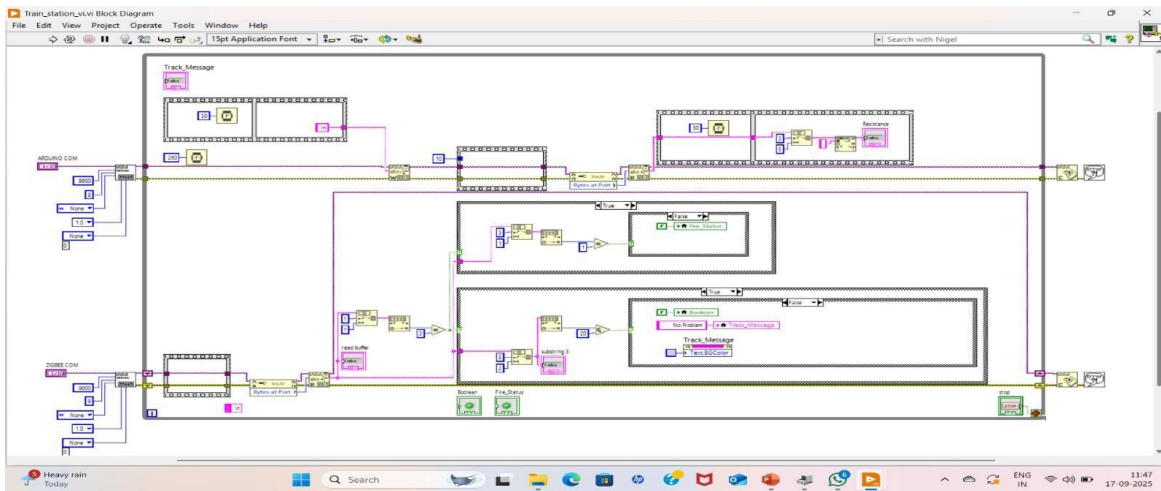


Fig 3: Railway Station Block Diagram

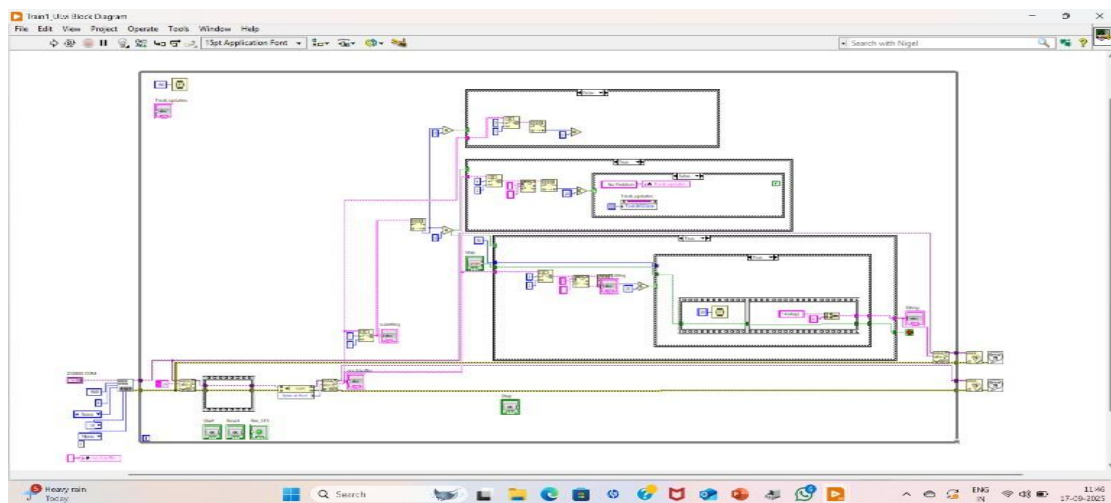


Fig 4: Train A Block Diagram

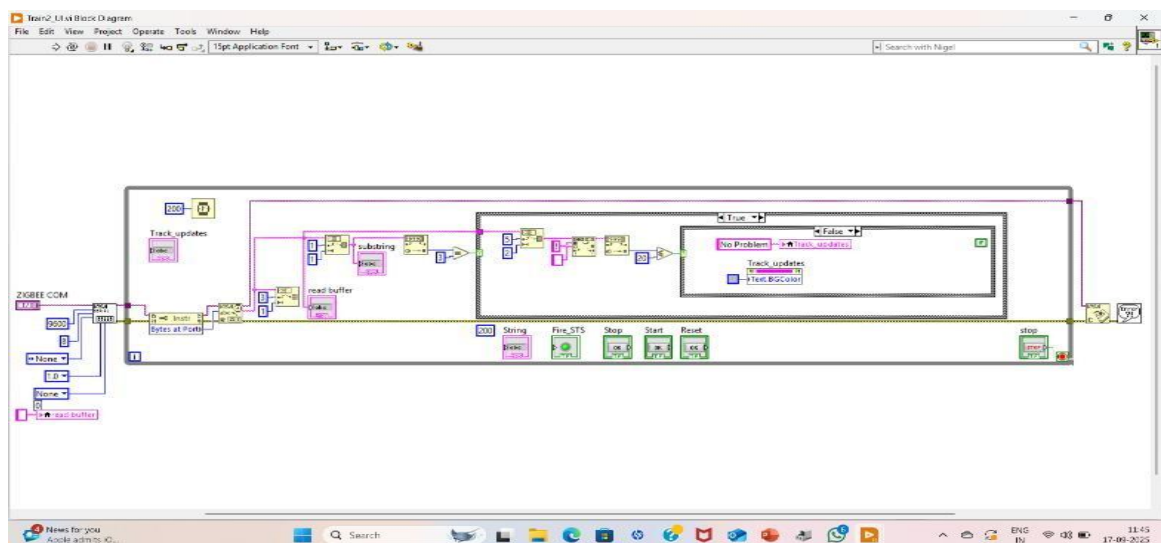


Fig 5: Train B Block Diagram



The LabVIEW block diagrams represent the software logic used to process sensor data, communicate with the Arduino controller, and display real-time railway safety information. Each section of the diagram is designed as a separate loop or structure that continuously executes specific tasks. The first main block handles serial communication, where data received from the Arduino through the COM port is read, filtered, and converted into meaningful values such as fire detection status, obstacle distance, and track resistance. These values are then passed to different case structures that activate corresponding indicators and alarms on the LabVIEW front panel. The middle portion of the diagram contains nested loops responsible for evaluating sensor thresholds and generating alerts when unsafe conditions are detected. For example, if the fire sensor sends a high signal, the system triggers a visual warning and activates an emergency indicator. Similarly, if the ultrasonic sensor detects an obstacle within a critical distance or if track resistance deviates from the normal range, the software updates the display and logs the event. The right-side blocks manage the communication with the ZigBee module and ensure wireless data transfer for remote monitoring. Finally, additional loops handle timing control, data buffering, and continuous updating of graphical displays. Together, these LabVIEW blocks implement real-time monitoring, decision-making, and alert generation for the integrated railway safety system. The LabVIEW system and also communicated to the train modules through Zigbee. The LabVIEW interface at the control station displays real-time data, including fire detection alerts and train positions. When a possible collision is detected or a fire alert is received, LabVIEW generates visual and audio warnings. This helps in taking preventive action such as stopping the train or alerting the driver immediately. Finally, the system is tested by simulating both fire and collision conditions to verify response time, accuracy, and the efficiency of Zigbee communication. The proposed model ensures safe train operation through intelligent monitoring, quick response, and effective communication between trains and the control station. The benefits of the Integrated Intelligent Railway Safety System are numerous. By providing real time monitoring and alerts, the system enables rapid response to potential hazards, reducing the risk of accidents and injuries. The system's proactive approach to safety, enabled by AI-powered predictive analytics, allows railway authorities to take preventive measures to avoid accidents, rather than simply responding to them after they occur. Overall, the Integrated Intelligent Railway Safety System offers a robust solution for improving railway safety, reducing the risk of accidents, and protecting the lives of passengers and crew. The visual indicators, Boolean flags, and data logs displayed on the LabVIEW front panel help operators observe system health and sensor behavior continuously. By combining hardware sensing with software-based intelligent decision-making, the LabVIEW implementation provides a complete automated solution for railway safety, enhancing both emergency response and preventive collision avoidance using IoT technology. The fire detection module analyses temperature and smoke sensor values and triggers an alert block when the predefined safety limit is exceeded. The collision avoidance module processes ultrasonic or IR sensor distance measurements and activates warning indicators or braking signals when an obstruction is detected on the track. All the processed data is transferred to an IoT communication unit, where LabVIEW publishes the safety status to the cloud through MQTT or HTTP protocols. This enables railway control centers and remote monitoring systems to receive alerts in real time.

IV. RESULTS

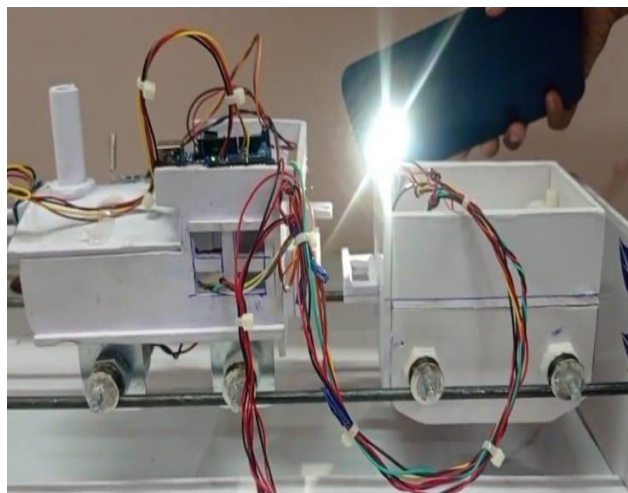


Fig.6: Fire Detection

The fire detection system in the railway model successfully identifies the presence of flame or abnormal heat using a fire sensor mounted on the train. When a fire source is detected, the sensor immediately sends a signal to the Arduino controller, which activates an alert mechanism. the system responds by turning on the indicator light and triggering



necessary safety actions. This demonstrates that the developed setup can quickly sense fire conditions and provide an early warning, helping to prevent accidents and ensure passenger safety.

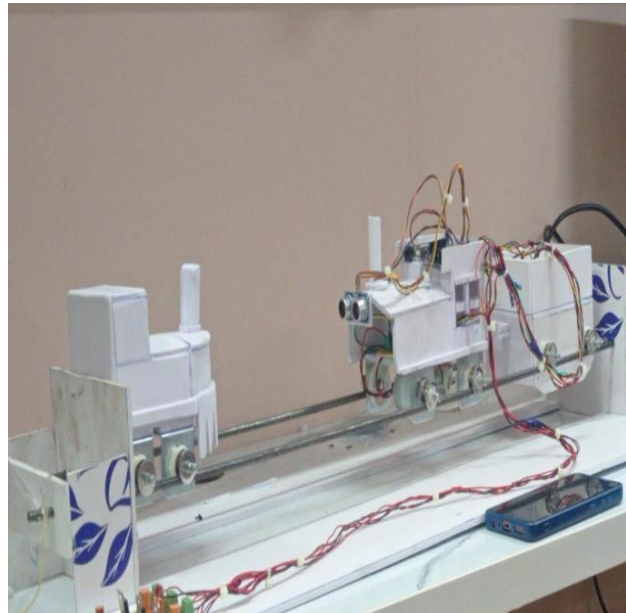


Fig.7: Collision Avoidance

The prototype model of a railway collision avoidance system, where two miniature trains are placed on the same track and equipped with sensors and control circuitry. The setup demonstrates how the system continuously monitors the distance between the trains using sensors and sends signals to the controller whenever the trains move too close. The controller then automatically slows down or stops the train to prevent a collision. This model visually represents the working principle of real-time detection, communication, and automated braking used in modern railway safety systems.



Fig.8: LabVIEW interface presenting combined fire detection and collision avoidance system

The Railway Station panel displays real-time track status, fire alerts, and track resistance values. When conditions are normal, the indicators appear in green; however, during a fault or danger such as two trains running on the same track—the interface highlights a red warning message. Similarly, the Train A and Train B panels visualize the fire status and track conditions for each train. The real-time sensor data is processed and displayed through LabVIEW, enabling quick identification of fire incidents and potential collision risks, thereby validating the functional accuracy of the system.



V. CONCLUSION

The proposed railway safety system integrating fire detection and collision avoidance has proven to be an effective and reliable solution for enhancing passenger safety. By using microcontroller-based sensing technologies, the system is capable of detecting fire at an early stage, alerting passengers safety. By using microcontroller-based sensing technologies, the system is capable of detecting fire at an early stage, alerting passengers and the loco pilot, and activating immediate safety measures to prevent the spread of fire. Similarly, the collision avoidance mechanism accurately identifies obstacles, abnormal track conditions, or the presence of another train, allowing timely intervention to avoid accidents. The combination of these two safety features provides a comprehensive protection system that significantly reduces risks during railway travel. Overall, this project demonstrates a practical, affordable, and efficient approach that can greatly improve safety standards in modern railways and contribute toward reducing train-related accidents.

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