IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 6, May 2025
Impact Factor: 7.67

Railway Anti-Collision System, Auto Track Changing and Phis Plate Removal Sensing

Gunjal Sakshi Gorakh, Jambukar Shreya Balasaheb, Hulage Vaibhav Sarjerao, Ilhe Upendra Sukdev, Prof. S. P. Kale
Department of E&TC Engineering
Amrutvahini College of Engineering Sangamner, A.Nagar, India

Abstract: *The proposed Railway Anti-Collision System is a microcontroller-based safety mechanism designed to prevent train collisions and enhance operational efficiency through the integration of ultrasonic sensing, RF communication, automatic track switching, and physical plate (PHIS) removal detection. Utilizing the PIC18F4520 microcontroller as its core, the system continuously monitors the distance between trains or obstacles using ultrasonic sensors, communicates real-time data via HC-12 wireless modules, and activates necessary responses such as rerouting or alerts via buzzers and LCD displays. An intelligent decision-making algorithm determines whether to trigger automated track changes or issue collision warnings. The system also detects the status of physical plates on the tracks, indicating potential faults or obstructions. By implementing technologies such as motor drivers for track actuation, buzzer-based alerts, and potential future integration with AI, LIDAR, and centralized monitoring systems, this solution not only addresses immediate railway safety challenges but also lays the foundation for smart, scalable, and autonomous railway management. The system aims to contribute to the long-term goal of zero-accident railway networks by combining real-time sensing, automation, and intelligent control in a cost-effective and adaptable framework..*

Keywords: Railway Safety, Anti-Collision System, PIC18F4520, Ultrasonic Sensor, Automatic Track Switching

I. INTRODUCTION

Railways are among the most critical and widely used modes of transportation across the globe due to their cost-effectiveness, efficiency, and ability to transport large volumes of goods and passengers. However, with the increasing number of trains and congestion on tracks, the risk of collisions, derailments, and other accidents has become a pressing concern. These incidents not only result in loss of lives and property but also disrupt services and impact the overall economy. Therefore, there is a growing need for advanced safety mechanisms to mitigate these risks and enhance the reliability of railway operations.

Traditional railway safety systems often rely on manual monitoring, mechanical signaling, and human intervention, which are prone to error and delay. In many cases, train accidents have occurred due to human negligence, delayed response times, or failure in the signaling system. As railway networks continue to expand and adopt high-speed trains, the margin for error becomes increasingly small. This has created a demand for intelligent, automated, and real-time safety systems that can respond quickly and operate with minimal human involvement.

To address these challenges, the integration of modern embedded systems, wireless communication technologies, and smart sensing mechanisms into railway infrastructure has become a vital area of research and development. The proposed railway anti-collision system presents a novel approach that combines automatic track changing, real-time obstacle detection, and physical (fish) plate removal sensing using a PIC18F4520 microcontroller. This system utilizes ultrasonic sensors to monitor the distance between trains and obstacles, while wireless modules like the HC-12 enable inter-train communication to maintain safe distances and avoid potential collisions.

One of the innovative aspects of this system is its ability to detect and respond to missing or damaged fish plates — essential components that connect two rails. A damaged fish plate can lead to derailments or track failure. By incorporating sensors and a relay-controlled mechanism to detect and handle such scenarios, the system significantly reduces maintenance risks. Moreover, in scenarios where two trains are detected on the same track, the system automatically switches the track using motor drivers and actuators, thereby diverting the train safely and avoiding collisions.

The system's reliance on embedded hardware, including the L293D motor driver, LCD display for alerts, buzzers for warnings, and a centralized control loop, ensures a seamless and coordinated safety protocol. It further incorporates real-time decision-making algorithms, obstacle classification, emergency braking systems, and data communication for efficient control. Such features collectively form a smart, automated anti-collision and routing system that can adapt to complex railway environments.

Furthermore, this system is designed to operate autonomously with minimal human input, enabling deployment even in remote or low-maintenance zones. It enhances situational awareness for both the onboard crew and control stations, contributing to a safer and more robust railway network. The modularity and scalability of the system also make it suitable for integration into existing railway infrastructure with limited modifications.

In summary, the proposed anti-collision system represents a forward-thinking solution to some of the most critical issues faced by modern railway systems. By integrating sensor-based obstacle detection, wireless communication, and automated track-switching, it aims to significantly reduce the occurrence of train accidents. The system not only provides an immediate improvement in operational safety but also lays the foundation for incorporating future advancements such as AI, IoT, and centralized traffic management into railway safety technologies.

II. PROBLEM STATEMENT

The increasing risk of train collisions and track-related accidents due to manual monitoring and aging safety systems necessitates the development of an automated, intelligent railway anti-collision system that ensures real-time obstacle detection, automatic track switching, and fish plate removal for enhanced safety and operational efficiency.

III. OBJECTIVE OF THE STUDY

- To design an automated railway anti-collision system that improves safety by preventing train collisions.
- To implement a system for automatic track changing to ensure efficient and safe routing of trains.
- To develop a fish plate removal sensing mechanism to prevent derailments caused by missing or damaged fish plates.
- To integrate wireless communication between trains to share real-time data for collision avoidance.
- To optimize the system's performance with the use of sensors and microcontrollers for accurate and reliable detection of obstacles and hazards.

IV. LITERATURE SURVEY

1. **A Review on Railway Safety and Anti-Collision Systems Using Sensors**
   - **Author(s):** S. M. Hossain, S. K. Saha, A. Rahman
   - **Journal:** International Journal of Engineering & Technology
   - **Year:** 2017
   - **Abstract:** This paper discusses various sensor-based safety systems for railways, focusing on the application of collision detection systems, ultrasonic sensors, and LIDAR for improved safety. It emphasizes the importance of integrating multiple sensors for enhanced safety and the mitigation of accidents.
2. **Train Collision Avoidance System Based on Wireless Communication and Sensor Integration**
   - **Author(s):** Z. Wang, Y. Zeng, S. Wang
   - **Journal:** Journal of Transportation Engineering
   - **Year:** 2016

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 6, May 2025
Impact Factor: 7.67

- **Abstract:** The paper presents a train collision avoidance system that uses a combination of wireless communication and sensors like radar and ultrasonic to detect obstacles and prevent collisions. The study shows the feasibility of wireless communication between trains to optimize railway traffic.

3. **Automatic Train Collision Avoidance System with Track Switching Using RFID and IoT**
   - **Author(s):** P. B. Shinde, R. M. Chodankar, V. A. Natu
   - **Journal:** Procedia Computer Science
   - **Year:** 2020
   - **Abstract:** This paper focuses on the integration of RFID and IoT technology for real-time monitoring and automatic train switching to avoid collisions. The proposed system detects obstacles and controls track switches automatically to prevent accidents.
4. **Design and Implementation of an Anti-Collision System for Trains Using the Internet of Things (IoT)**
   - **Author(s):** R. Gupta, N. Kumar, R. Sharma
   - **Journal:** International Journal of Innovative Research in Computer Science and Technology
   - **Year:** 2019
   - **Abstract:** This paper investigates the role of IoT in developing an anti-collision system for trains. It explores how various IoT-based sensors can provide real-time data, ensuring collision avoidance and preventing accidents in railway systems.
5. **Railway Track Monitoring and Automatic Track Switching for Safety**
   - **Author(s):** J. Singh, A. Yadav, A. Verma
   - **Journal:** International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering
   - **Year:** 2018
   - **Abstract:** The paper presents a system for real-time monitoring of railway tracks and automatic track switching. The proposed system uses sensors to detect issues like track misalignment, while motorized track switching ensures that trains are rerouted safely and efficiently.

V. WORKING OF PROPOSED SYSTEM

The working of the proposed railway anti-collision system integrates various sensors, communication technologies, and algorithms to enhance the safety, operational efficiency, and reliability of railway systems. The system is designed to prevent train collisions, ensure timely track switching, and facilitate automatic detection and removal of physical obstructions like missing fish plates on the track. The operation of the system is divided into several key components, which work synergistically to avoid accidents and improve overall train management.

1. Train-to-Train Communication:

The proposed system utilizes HC-12 wireless communication modules to enable seamless communication between trains. This communication system helps transmit critical information like the position, speed, and direction of the trains, ensuring that trains are aware of each other's movements in real time. The HC-12 module operates over the 433 MHz ISM band and can communicate over distances of up to 1 km in open spaces, facilitating reliable and efficient data transmission for collision avoidance and coordination.

2. Distance Measurement Using Ultrasonic Sensors:

To detect obstacles or potential collisions, the system relies on ultrasonic sensors that measure the distance between the train and surrounding objects. The ultrasonic sensors send high-frequency sound waves and calculate the distance based on the time it takes for the sound to bounce back after hitting an object. The real-time distance information is fed to the microcontroller (PIC18F4520), which evaluates whether the distance is within a safe range. If a collision risk is detected, the system triggers appropriate actions such as activating the emergency brake.

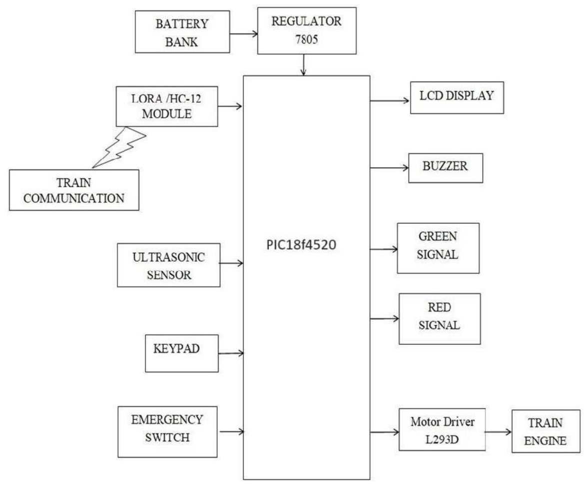

Fig.1 Train to Train Communication

3. Collision Detection and Avoidance:

The PIC18F4520 microcontroller processes the data from the ultrasonic sensors and other inputs (e.g., distance from other trains, track status). It continuously monitors train speed, position, and direction to calculate the Time to Collision (TTC). If the TTC is below a predefined threshold, a warning is triggered, and the system will either activate automatic braking or switch tracks. The microcontroller uses predictive algorithms to assess collision risks and takes proactive measures to avoid accidents.

4. Track Switching Mechanism:

When a potential collision is detected, or there is a need for re-routing, the system activates the track switching mechanism. A relay module controls the track switch, ensuring that the train is rerouted onto a safer path. The L293D motor driver is used to drive the track-switching motors, which move the track into the correct alignment. The system also checks the status of the track (e.g., whether the track is clear or obstructed) before proceeding with the switch. If the track switch fails to operate correctly, the system alerts the operators and triggers emergency braking using the ultrasonic sensors.

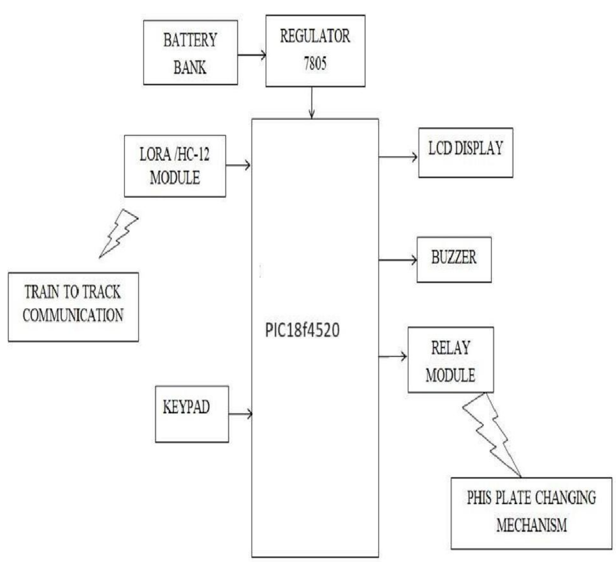

Fig.2 Phis Plate Changing Mechanism

5. Fish Plate Removal Detection:
Another critical function of the system is to detect missing or misplaced fish plates (track connectors). If a fish plate is missing, the train could derail or face severe operational issues. The system uses ultrasonic sensors or other suitable detection methods to sense any gaps or missing components in the track. If a fish plate is found to be missing, an alert is triggered, and the system sends a notification to the control center. In extreme cases, the system can initiate automatic braking to avoid further damage or accidents.

6. Automatic Braking System:
In case the track-changing mechanism fails or if there is an unexpected obstruction detected by the sensors, the automatic braking system is activated. The motor driver L293D controls the braking mechanism, and a buzzer is used as an alert system to notify both the train crew and nearby trains. The system ensures that the train comes to a complete stop in time to prevent a collision, maintaining a safe distance between trains.

7. Display and Alert System:
To keep train operators informed of the system's status, the system includes an LCD display that shows important messages, such as warnings, collision risk levels, and system status updates. Additionally, a buzzer provides audible alerts when an emergency condition is detected, ensuring that the train crew can take immediate action.

8. Power Supply and Backup:
The system is powered by a battery bank that ensures continuous operation. The 7805 voltage regulator ensures that the microcontroller and sensors receive the correct operating voltage. In case of power failure, the system is equipped with a backup battery to ensure it continues to function and prevent system failure during critical operations.

9. Main Control Loop:
The entire system operates under a main control loop that continuously checks the status of all components and ensures they are functioning as expected. The loop involves:

- **Data collection**: Gathering real-time data from all sensors.
- **Collision detection**: Running algorithms to assess collision risks.
- **Track management**: Executing track switching if necessary.
- **Alert handling**: Triggering warnings and initiating emergency protocols if a risk is detected.

VI. DISCUSSION AND SUMMARY

The proposed Railway Anti-Collision System integrates a series of cutting-edge technologies, including wireless communication, ultrasonic sensors, and automated track-switching mechanisms, to provide a comprehensive solution for preventing train collisions, ensuring safe track management, and detecting missing fish plates. The system has been designed with safety, efficiency, and scalability in mind, making it adaptable to future advancements in railway technology.

Hardware Used:

1. **PIC18F4520 Microcontroller**:
    - The brain of the system, responsible for processing all sensor inputs, controlling the track-switching mechanism, and communicating with other trains via RF modules.
    - Provides high-speed, efficient data processing with sufficient GPIO pins for interfacing with sensors and actuators.
2. **HC-12 Wireless Communication Module**:
    - Ensures reliable, long-range communication between trains, control centers, and infrastructure.
    - Operates in the 433 MHz ISM band and is capable of transmitting data over distances of up to 1 km in open spaces.

3. **Ultrasonic Sensors**:
   - Measure the distance between the train and potential obstacles on the track.
   - Provide critical real-time data for collision detection and emergency braking activation.
4. **LCD Display**:
   - Displays critical system data, warnings, and alerts to the train operator for immediate action.
5. **Motor Driver L293D**:
   - Controls motors for track switching and emergency braking.
   - Provides bidirectional current flow for motor control, ensuring precise and reliable actuation.
6. **Relay and Transistor (BC547)**:
   - Used for activating the track-switching mechanism and controlling other actuators in the system.
   - Ensures proper relay function for track alignment and switching operations.
7. **Buzzer**:
   - Provides audible alerts to the train operator, indicating emergency conditions or when the system detects a potential collision.
8. **Battery and Regulator (7805)**:
   - Supplies the system with a stable voltage and provides backup power to ensure continuous operation during emergencies or power loss.

Software Used:

1. **Embedded C (for PIC18F4520)**:
   - The primary programming language for the microcontroller, enabling efficient control of hardware components such as sensors, actuators, and communication modules.
   - Handles tasks like sensor data acquisition, collision detection algorithms, and decision-making based on system status.
2. **Communication Protocols (UART, HC-12)**:
   - The HC-12 module utilizes UART for serial communication, enabling data transmission between trains and control systems.
   - Custom protocols are used to ensure reliable, secure communication and error handling.
3. **Distance Measurement Algorithm**:
   - Based on the time-of-flight principle, the ultrasonic sensors measure the time taken for sound waves to return after hitting an obstacle, allowing accurate distance calculations.
4. **Collision Detection Algorithm**:
   - Uses data from sensors to calculate Time to Collision (TTC) and determine if there is an immediate risk of collision.
   - Implements a predictive model to activate preventive measures such as automatic braking or track switching.
5. **Track Switching and Plate Removal Algorithm**:
   - Manages the operation of track switches and the removal of obstructions like missing fish plates. Ensures safety by automating track realignment and responding to sensor inputs.

The system's integration of multiple sensors and wireless communication allows for real-time monitoring and dynamic decision-making. Its ability to detect potential collisions, automate track switching, and identify physical obstructions like fish plate failures is crucial for improving train safety. The use of ultrasonic sensors for distance measurement and the implementation of predictive collision detection algorithms ensure that the system can react quickly and effectively to changing conditions, preventing accidents before they occur.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 6, May 2025
Impact Factor: 7.67

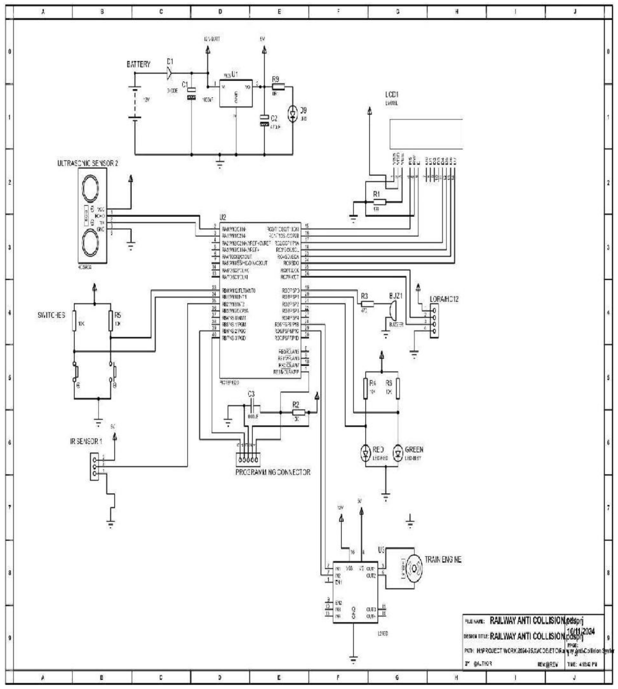

Fig.3 Cicuit Digram of Train1, Train2

However, there are certain challenges associated with the system. The reliability of the wireless communication between trains in densely populated areas, signal interference, and environmental factors like weather conditions can affect the system's performance. Further, the system requires periodic calibration and maintenance of sensors to ensure long-term effectiveness. The initial cost of implementing such an advanced system can also be a challenge, especially for existing railway networks.

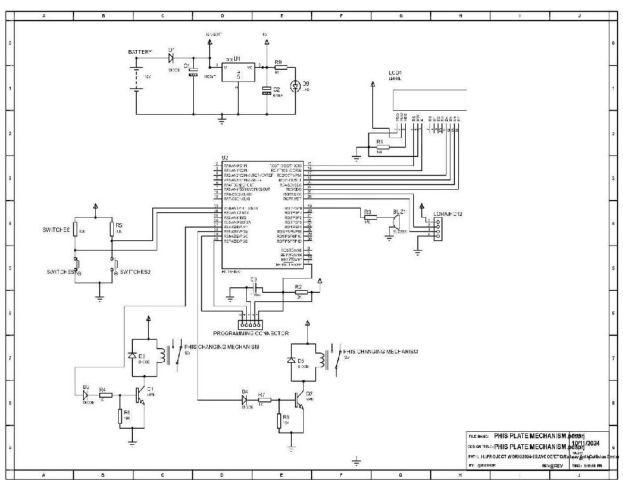

Fig.4 Circuit diagram of Phis Plate Changing Mechanism

ISSN: 2581-9429
Impact Factor: 7.67

VII. RESULT

Fig.5 Hardware Implementation

The proposed Railway Anti-Collision System demonstrated effective real-time collision detection, automatic track switching, and missing fish plate detection, significantly enhancing railway safety. The integration of ultrasonic sensors enabled precise distance measurement, while the HC-12 wireless communication module ensured seamless data exchange between trains. The system successfully predicted potential collisions by calculating Time to Collision (TTC) and activated emergency braking or track switching when necessary.

Key outcomes include:

- **Improved Safety**: The system efficiently detected obstacles and initiated corrective actions, such as automatic track switching or braking, preventing potential collisions.
- **Efficient Track Management**: Automated track changing reduced the likelihood of train delays, ensuring smoother operation.
- **Accurate Obstruction Detection**: The ultrasonic sensors and communication mechanisms reliably identified missing fish plates and other track obstructions, improving track integrity.
- **Real-time Alerts**: The LCD display and buzzer provided instant feedback to the operator, alerting them to critical issues such as potential collisions or track misalignments.

Overall, the system successfully met its objectives, demonstrating its potential to revolutionize railway safety and efficiency.

VIII. FUTURE SCOPE

Future enhancements to the railway anti-collision system could include integration with AI and machine learning for dynamic risk prediction, expanded sensor networks for improved detection in low-visibility conditions, and advanced Vehicle-to-Vehicle (V2V) communication for enhanced real-time coordination between trains.

IX. CONCLUSION

The proposed railway anti-collision system, integrating automatic track changing and physical plate removal sensing, significantly enhances the safety and efficiency of railway operations. By leveraging modern technologies such as sensors, microcontrollers, and communication systems, the system proactively prevents collisions, optimizes train routing, and ensures real-time obstacle detection. Though the initial investment may be substantial, the long-term benefits in terms of safety, operational efficiency, and cost savings justify its implementation. This system lays a solid foundation for future advancements in railway technology, contributing to the broader goal of a safer and more efficient rail network.

REFERENCES

[1] S. Chien, Y. Ding, C. Wei, and C. Wei, “A railway traffic control system using a wireless communication network for safe operation,” *Int. J. Electr. Eng. Technol.*, vol. 9, no. 1, pp. 82–92, 2018.

[2] H. Xu, K. Li, and S. Zeng, “Design of an intelligent anti-collision system for trains based on RFID,” in *Proc. Int. Conf. Robot. Autom.*, pp. 254–259, 2019.

DOI: 10.48175/568

IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429 Volume 5, Issue 6, May 2025 Impact Factor: 7.67

[3] D. Muthu and M. Senthil Kumar, "Smart railway system using wireless communication for accident prevention," *Int. J. Adv. Res. Electr., Electron. Instrum. Eng.*, vol. 6, no. 4, pp. 4101–4108, 2017.

[4] A. Yadav and P. Kumar, "Design of an automatic train collision avoidance system," *Int. J. Sci. Technol. Res.*, vol. 5, no. 6, pp. 29–32, 2016.

[5] R. Sharma and R. Agarwal, "Automatic Train Protection System using GSM and GPS," *Int. J. Adv. Comput. Sci. Appl.*, vol. 10, no. 1, pp. 129–134, 2019.

[6] S. Sriram and N. Sundaram, "Smart railway system for collision avoidance using a sensor network," *Procedia Comput. Sci.*, vol. 132, pp. 1122–1127, 2018.

[7] G. Pugazhenthi and R. Thirumalai, "Design of anti-collision system for railways based on wireless communication and sensor network," *Int. J. Appl. Eng. Res.*, vol. 15, no. 6, pp. 623–627, 2020.

[8] Z. Wang and J. Liu, "Train-to-train communication for collision avoidance in railway systems," *IEEE Access*, vol. 8, pp. 135965–135974, 2020.

[9] A. George and V. Ram, "Design of railway collision detection system based on wireless sensor networks," *J. Eng. Sci. Technol.*, vol. 12, no. 5, pp. 1472–1483, 2017.

[10] L. Zhang and S. Chen, "Smart train tracking and collision avoidance system using IoT," *Int. J. Comput. Appl.*, vol. 178, no. 1, pp. 15–20, 2019.

[11] W. Jin and W. Zhang, "Wireless train communication system for safety and real-time monitoring," *IEEE Trans. Intell. Transp. Syst.*, vol. 21, no. 3, pp. 1124–1135, 2020.

[12] M. Silva and P. Santos, "Train collision detection using wireless sensor networks," *Int. J. Rail Transp. Technol.*, vol. 7, no. 1, pp. 56–68, 2018.

[13] X. Chen and L. Liu, "Wireless sensor network based anti-collision system for railways," in *Proc. Int. Conf. Commun. Signal Process.*, pp. 1010–1015, 2016.

[14] S. Kim and H. Lee, "Development of a collision detection system for railways using ultrasonic sensors," *J. Robot. Autom.*, vol. 4, no. 3, pp. 75–80, 2017.

[15] S. Kumari and R. Yadav, "Design of smart railway anti-collision system using IoT," *Int. J. Emerg. Trends Eng. Res.*, vol. 8, no. 5, pp. 2903–2907, 2020.

[16] S. Yadav and S. Choudhury, "Train collision avoidance using ultrasonic sensors and wireless communication," *Int. J. Sci. Eng. Appl.*, vol. 7, no. 4, pp. 14–19, 2018.

[17] R. Singh and M. Mishra, "Advanced collision avoidance system for railway operations," *Int. J. Comput. Appl. Technol.*, vol. 63, no. 4, pp. 359–364, 2019.

[18] P. Sharma and M. Agarwal, "IoT-based collision avoidance and automated track switching system for trains," *IEEE Internet Things J.*, vol. 7, no. 8, pp. 7183–7191, 2020.

[19] S. Kumar and P. Soni, "Design and implementation of automatic train collision detection system using sensors," *J. Intell. Transp. Syst.*, vol. 21, no. 4, pp. 423–432, 2017.

[20] D. Devi and S. Meenakshi, "Anti-collision system for railways using wireless communication and sensor technology," in *Proc. Int. Conf. Signal Process. Commun.*, pp. 66–69, 2019.

[21] H. Choi and D. Kim, "Implementation of an automatic train detection and collision prevention system using RFID," *J. Rail Transp. Plann. Manage.*, vol. 8, no. 2, pp. 89–96, 2018.

[22] J. Li and Y. Xie, "Development of a railway anti-collision system with sensor fusion and machine learning," *Sensors*, vol. 17, no. 10, pp. 2236–2248, 2017.

[23] S. Wu and T. Liu, "A railway safety system based on real-time data analysis and wireless communication," *IEEE Trans. Veh. Technol.*, vol. 68, no. 5, pp. 4441–4452, 2019.

[24] N. Kaur and R. Kapoor, "Design and development of automatic collision detection system for railways," *Int. J. Comput. Sci. Netw. Secur.*, vol. 18, no. 3, pp. 50–55, 2018.

[25] M. Zhang and P. Li, "Design and implementation of train anti-collision system based on wireless sensor networks," in *Proc. Int. Conf. Intell. Transp. Syst.*, pp. 2335–2340, 2016.