



International Journal of Engineering Research and Science & Technology

www.ijerst.org

ISSN : 2319-5991

Vol. 22 No. 4 (2026)



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Research Paper**Automated [Zero Manpower] Railway Crossing-1****Prof. C. A.Chitkeshwar****Akash Dnyaneshwar Meshram****SHUBHAM MURLIDHAR KANETKAR****Vedant pravin wasu****Jay Kisan Sawant****Mohammad Mubashshir Abdul nisar****DRGITR (Poly), Amravati, Maharashtra , India****Abstract**

Railway level crossings are critical interfaces between railway tracks and road traffic. Conventional manually operated level crossings require continuous human presence for monitoring train movement, operating gates, providing warnings, and managing road traffic. Human error, delayed response, poor visibility, fatigue, and communication failures can increase the risk of accidents. This paper proposes an Automated Zero-Manpower Railway Crossing (AZMRC) system in which train detection, warning generation, gate operation, obstacle monitoring, and remote status reporting are performed automatically.

The proposed system uses a combination of railway-compatible train-detection sensors, obstacle-detection sensors, a safety-oriented control unit, automatic barriers, warning lights, audible alarms, emergency controls, and wireless communication. The system detects an approaching train, determines its direction and estimated arrival, activates road-user warnings, closes the barriers after ensuring that the crossing is clear, continuously monitors the crossing area, and reopens the barriers only after the train has completely cleared the protected section. A redundant sensing approach is proposed so that failure of an individual sensor does not result in an unsafe gate operation.

Recent research demonstrates the feasibility of combining infrared/ultrasonic sensing, long-range wireless communication, microcontrollers, and automatic gate control for railway crossings. IEEE Xplore+1 Indian Railway specifications also emphasize level-crossing monitoring, warning arrangements, gate control, communication, and failure indication. RDSO+1 The proposed system therefore focuses not merely on automatic gate movement but on a fail-safe, redundant and remotely supervised railway-crossing architecture.

Keywords: Railway Level Crossing, Zero Manpower, Automatic Gate, Train Detection, Obstacle Detection, IoT, Wireless Communication, Railway Safety, Embedded System, Fail-Safe Control.

1. Introduction

Railways provide an efficient and high-capacity mode of transportation, but railway infrastructure intersects with road networks at numerous level crossings. At these locations, trains and road vehicles occupy the same physical corridor at different times. A railway train requires a considerably longer stopping distance than a road vehicle; consequently, preventing unauthorized road traffic from entering the crossing before a train arrives is a fundamental safety requirement.

Traditional railway crossings may depend on manual gatekeepers to observe train movements and operate barriers. Such arrangements introduce a human element into a safety-critical

operation. Problems may occur because of fatigue, poor visibility, communication failure, incorrect estimation of train arrival, delayed gate operation, or unauthorized road-user behavior.

Automation can reduce dependence on continuous human intervention. Modern railway research has investigated systems based on infrared sensors, ultrasonic sensors, wireless communication, microcontrollers, cameras, LiDAR and artificial intelligence. For example, recent research has demonstrated an IoT-based railway-crossing gate system using IR and ultrasonic sensors with long-range LoRa communication and automatic gate control. IEEE Xplore Another 2025 study developed an IoT-based automatic railway portal using LoRa, ultrasonic sensing, servo actuation and remote data visualization.

The objective of the present work is to develop a conceptual Automated Zero-Manpower Railway Crossing that can automatically perform the major functions normally associated with a manned crossing while maintaining appropriate safety redundancies.

2. Problem Statement

A manually operated railway crossing requires personnel to continuously monitor train movements and road traffic and to operate the crossing equipment at the correct time. This approach has several limitations:

- Dependence on human availability.
- Possibility of human error.
- Delayed gate operation.
- Fatigue during long operating periods.
- Difficulty in monitoring during poor weather or visibility.
- Requirement for communication between railway personnel.
- Operating and staffing costs.
- Limited automatic detection of vehicles or pedestrians trapped inside the crossing.
- Limited remote visibility of equipment health.

The problem addressed by this research is therefore:

To design an automated railway-level-crossing system capable of detecting approaching and departing trains, controlling barriers, warning road users, detecting obstructions, reporting failures remotely, and operating without a permanently stationed gatekeeper.

The term “zero manpower” in this paper refers specifically to zero permanent manpower at the crossing for routine gate operation. It should not be interpreted as zero human involvement in inspection, maintenance, emergency response, or railway traffic control.

3. Objectives

The major objectives are:

1. To automatically detect an approaching train.
2. To determine the direction of train movement.
3. To estimate the train's arrival at the crossing.
4. To activate visual and audible warnings.
5. To automatically close the road barriers.
6. To prevent barrier closure when the crossing is not safely clear.
7. To detect vehicles, pedestrians or other obstacles remaining within the crossing.
8. To monitor the complete passage of the train.
9. To automatically reopen the barriers after the protected section is confirmed clear.
10. To transmit crossing status and fault information to a remote control centre.
11. To provide backup power during electrical failure.
12. To implement a fail-safe philosophy in which uncertain sensor conditions result in a safe state rather than an unsafe opening of the crossing.

4. Literature Review

4.1 IoT-Based Railway Crossing Systems

Recent research has proposed IoT-based railway gate-control systems using multiple sensors and wireless communication. One system uses IR and ultrasonic sensors to detect approaching trains and employs LoRa communication to transmit information between the train-detection and gate-control sections.

Another recent study proposed an automatic railway portal system using LoRa, Arduino, ultrasonic sensors, LEDs, buzzers and servo motors. The experimental prototype automatically closed and reopened the portal based on train detection and transmitted information to a web dashboard.

These studies demonstrate the potential of low-power wireless communication and distributed sensing, although a real railway deployment would require considerably more rigorous safety validation than a laboratory prototype.

4.2 Obstacle Detection

Detecting a train alone is insufficient. A vehicle, pedestrian, animal or object may remain trapped between the barriers. Therefore, obstacle detection should form an independent safety layer.

Modern railway research is increasingly investigating camera-based and AI-based obstacle detection. A 2025 IEEE study proposed a real-time railway obstacle-detection system based on multitask perception, combining object detection with railway-track segmentation and risk assessment.

Another recent review examined cameras, LiDAR and millimeter-wave radar for railway obstacle-intrusion detection and discussed sensor fusion and AI-based detection approaches. [1] These technologies could enhance an automated crossing, but they should not be treated as the sole safety mechanism without appropriate railway safety certification.

4.3 Indian Railway Requirements

The Research Designs & Standards Organisation (RDSO) of Indian Railways publishes technical specifications relevant to railway signalling and level-crossing systems. RDSO documentation covers level-crossing gate control and monitoring equipment using wired and wireless communication.

RDSO's signalling safety handbook also identifies requirements concerning electric lifting barriers, audio/visual warnings, approach-warning arrangements, communication and maintenance of gate equipment.

The Indian Railway Kavach specification also recognizes level-crossing information and automatic locomotive warning functions. The specification describes automatic whistling on approach to a level crossing and the use of level-crossing gate information.

These documents indicate that an automated crossing should be considered as part of a broader railway signalling and safety ecosystem rather than as an isolated electronic gate.

5. Proposed System

The proposed AZMRC system consists of the following major subsystems:

1. Train detection system.
2. Train direction and occupancy determination.
3. Central safety controller.
4. Automatic barrier mechanism.
5. Warning system.
6. Crossing-area obstacle detection.
7. Emergency and manual override system.
8. Communication and remote monitoring.

9. Power supply and backup system.
10. Event logging and diagnostics.

Conclusion

The proposed architecture moves beyond simple automatic gate operation. A reliable railway crossing should detect the train, establish the direction and occupancy of the railway section, warn road users, control barriers, monitor the crossing for trapped objects, verify train departure and continuously report abnormal conditions.

The central principle of the proposed system is therefore automation with fail-safe redundancy rather than automation alone. A properly engineered system can reduce dependence on continuous manpower while improving consistency, monitoring and response. For practical deployment, however, the design must undergo detailed safety analysis, railway-specific engineering, testing, certification and regulatory approval.

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