

# Smart Railway Track Monitoring for Crack Detection Using GSM and GPS

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**Abstract** — Indian Railways operates one of the largest railway networks, where track cracks pose serious safety risks. Traditional manual inspection methods are time-consuming, labor-intensive, and prone to human error. This paper presents a smart railway track monitoring system for real-time crack detection. The system continuously monitors track conditions and autonomously detects cracks and irregularities. Upon detection, alert messages with precise GPS coordinates are transmitted to authorities using GSM technology. This enables quick maintenance response and prevents potential accidents. The proposed system reduces human intervention and inspection time. It also enhances railway safety, reliability, and operational efficiency.

**Keywords:** Railway Safety, Crack Detection, GSM, GPS

## I. INTRODUCTION

Railways are one of the most important modes of transportation in India, supporting both passenger travel and freight movement across the country. Due to the vast size of the railway network, ensuring track safety is a major challenge, especially because cracks and structural defects can develop due to temperature variations, material fatigue, poor maintenance, and external vibrations. If these defects are not detected in time, they can lead to serious accidents and derailments. Traditional manual inspection methods are slow, labor-intensive, and prone to human error, making them inefficient for continuous monitoring. To overcome these limitations, the proposed Smart Railway Track Monitoring system uses an automated robotic unit equipped with sensors to detect cracks and obstacles on railway tracks. When a defect is identified, the system immediately sends an alert along with the exact GPS location using GSM communication. This enables quick maintenance response, improves railway safety, reduces accidents, and supports the development of a smart and reliable railway infrastructure.

## II. PROBLEM STATEMENT

Indian Railways plays a very important role in transporting passengers and goods across the country, but ensuring track safety remains a major challenge. One of the main reasons for railway accidents and derailments is the presence of cracks and structural defects in railway tracks, which often go unnoticed until a serious failure occurs. These defects may develop due to temperature changes, heavy train loads, poor-quality materials, corrosion, and delayed maintenance. At present, railway track inspection is mainly carried out manually by patrol teams, which is a slow and labor-intensive process. This method is also prone to human error and does not allow continuous or real-time monitoring, especially in long and remote track sections. As a result, early detection and timely maintenance of track defects become difficult, increasing the risk of accidents.

## III. LITERATURE SURVEY

A detailed literature survey was conducted to study existing methods and technologies used for crack detection in road and railway track monitoring systems. This review helps in understanding the advantages, limitations, and research gaps in current systems and provides a strong foundation for the proposed work

- 1) Rijoy Paul et al. [1] developed a railway track crack detection system using Raspberry Pi 3 combined with image processing and ultrasonic sensors. The system detects cracks or deformations on the track and determines their exact geographical location using GPS. The detected information is transmitted to railway authorities via Wi-Fi or SMS, significantly reducing dependence on manual inspection, which is time-consuming and labour-intensive.
- 2) Anand S. Muley et al. [2] proposed a GSM-based railway track crack detection system using an operational amplifier and a microcontroller. Their approach provides a simple and cost-effective solution for detecting cracks in railway tracks. When a crack is detected, an alert message is transmitted to the main control branch through GSM communication, emphasizing simplicity and affordability.
- 3) Rizvi Aliza Raza et al. [3] presented an automated railway track crack detection system based on image processing techniques. Their method replaces traditional manual inspection by installing video cameras along railway tracks to continuously capture images. Cracks are automatically detected from the captured data, enabling early fault identification, reducing accident risks, and minimizing manpower requirements.
- 4) Lad and Pawar [4] proposed an evolved railway track crack detection system integrating GPS, GSM, IR, and PIR sensors. Their system focuses on crack detection, real-time communication, and accurate location tracking. The PIR sensor detects the presence of living beings on the track, while GPS and GSM modules transmit crack location details to nearby railway stations, enhancing safety during both daytime and nighttime operations.
- 5) Henrique Oliveira and Paulo Lobato Correia [5] presented an image-based crack detection and characterization technique using a two-dimensional feature space. Their approach involves capturing surface images and extracting crack features such as length, width, and overlapping characteristics

## IV. HARDWARE COMPONENTS

The Smart Railway Track Monitoring System consists of the following major components:

- 1) Arduino Uno Microcontroller (ATmega328P, 16 MHz clock, 14 digital I/O pins, 6 analog inputs, 5 V operation): It is the main controller of the system. It receives data from sensors, processes it, and controls GSM, GPS, motors, and alerts based on the detected faults.
- 2) IR Sensors (Crack Detection Operating voltage: 3.3 V, IR transmitter & receiver pair): These sensors are used to detect cracks or gaps in the railway track. When a crack is present, the reflected infrared signal changes, indicating a fault.
- 3) Ultrasonic Sensor (Obstacle Detection Range: 2 cm–400 cm, Frequency: 40 kHz): This sensor detects obstacles on the track by sending and receiving ultrasonic waves. It helps prevent accidents by identifying objects ahead of the robot.
- 4) GSM Module (Quad band (850/900/1800/1900 MHz), 3.8–4.2 V): The GSM module sends alert messages to railway authorities. It informs them immediately when a crack or obstacle is detected.
- 5) GPS Module (50 channels, accuracy  $\pm 2.5$  m, UART interface): GPS provides the exact location of the detected fault. This helps maintenance teams quickly reach the problem area.
- 6) 16 $\times$ 2 LCD Display (16 characters  $\times$  2 lines, 5 V supply): The LCD displays system status, sensor readings, and fault messages. It helps in easy monitoring of system operation.
- 7) Relay Module (5 V coil voltage, SPDT): The relay acts as an electrically controlled switch. It allows safe control of motors or alarms using low-power signals from Arduino.
- 8) DC Gear Motors with Wheels(30 RPM, 12 V DC with Plastic/rubber wheels): These motors move the robotic unit along the railway track. Gear motors provide sufficient torque for smooth movement.
- 9) Buzzer(5 V Piezo buzzer,  $\sim 4$  kHz): The buzzer gives an audible alert when a fault is detected. It provides immediate local warning.
- 10) Regulated Power Supply (7805): This ensures a constant 5V supply to electronic components. It protects the system from voltage fluctuations.
- 11) Battery (Lead-acid / Li-ion, 12 V DC): The battery provides portable power to the system. It allows the robot to operate without external power sources.
- 12) Supporting Components: Components like resistors and capacitors stabilize signals and protect circuits. PCB and wiring ensure proper electrical connections.

## V. METHODOLOGY

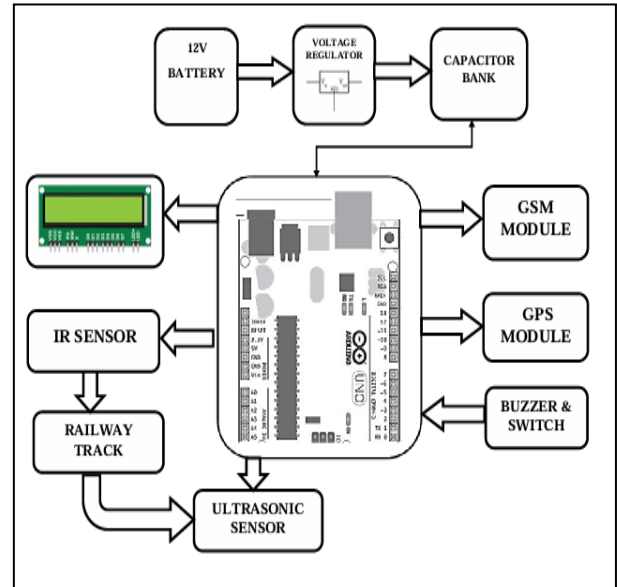


Fig. 1: Block Diagram of the Smart Railway Track Monitoring System

Overall Block Diagram Flow:

- 1) Power supply enters the system and energizes all components.
- 2) IR sensors monitor the railway track surface and generate signals based on crack presence.
- 3) Ultrasonic sensor measures distance to detect obstacles on the track.
- 4) Sensor output signals are sent to the Arduino UNO microcontroller.
- 5) The microcontroller samples and processes sensor data using predefined logic.
- 6) The microcontroller determines normal or faulty track condition.
- 7) Upon fault detection, the microcontroller deactivates the relay to stop the motors.
- 8) The GPS module provides the geographical location of the detected fault.
- 9) The GSM module transmits an SMS alert containing fault details and GPS coordinates.
- 10) LCD displays system status and the buzzer provides an audible alert.
- 11) The system continuously repeats the monitoring and detection process.

The flowchart represents the operational sequence of the Smart Railway Track Monitoring System for Crack Detection using GSM and GPS. It illustrates the step-by-step functioning of the system from initialization to fault detection and alert transmission. The process begins with the Start block, which indicates the powering ON of the system. Once the system is powered, all hardware components such as the Arduino microcontroller, IR sensors, ultrasonic sensor, relay, GSM module, GPS module, and LCD display are initialized. After successful initialization, the LCD displays a readiness message, confirming that the system is prepared for operation. Next, the relay is energized, allowing power to be supplied to the DC motors. As a result, the robotic platform starts moving along the railway track. While the robot is in motion, the system continuously reads data from the IR

sensors and ultrasonic sensor to monitor the condition of the track. The sensor data is processed by the microcontroller, and a decision block checks whether a crack or obstacle is detected. If no fault is detected, the flow returns to the sensor monitoring stage, allowing continuous inspection of the track. If a crack or obstacle is detected, the flow moves to the fault-handling stage. The relay is immediately turned OFF, which stops the motors and prevents further movement of the robot. Simultaneously, the buzzer is activated, and the LCD displays a fault message indicating either crack detection or obstacle detection. After stopping the robot, the GPS module is activated to obtain the exact geographical coordinates (latitude and longitude) of the detected fault location. Once the location data is acquired, the GSM module sends an SMS alert containing the fault type and location details to the predefined mobile number or railway control centre. Finally, after successful alert transmission, the system reaches the End block, indicating completion of the detection and reporting cycle. The system may then wait for manual reset or resume monitoring based on system configuration.

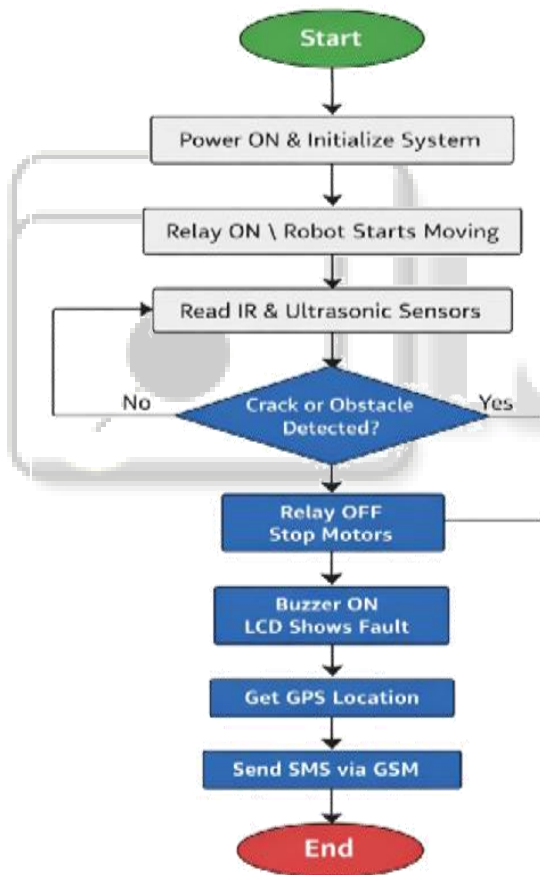


Fig. 2: System Methodology Flowchart

## VI. APPLICATIONS

The Railway Monitoring System is suitable for a wide range of real-world applications:

- 1) Passenger Safety and Convenience Real-time train tracking, alerts for signal status, and obstacle detection enhance passenger safety and improve travel convenience.

- 2) Station and Track Management Automated monitoring of gates, signals, and track conditions reduces manual inspections and improves operational efficiency.
- 3) Railway Control Centres Integration with central railway control systems enables remote monitoring, automated decision-making, and coordinated train management.
- 4) Level Crossing Automation IoT-based control allows automatic operation of level crossing gates and warning signals, minimizing human intervention.
- 5) Accident and Fault Prevention Detection of track faults, obstacles, or unauthorized access helps prevent accidents and ensures timely maintenance.
- 6) Educational & Research Projects Ideal for embedded systems, IoT, and railway engineering research projects, providing practical learning opportunities.

## VII. FUTURE SCOPE

- 1) Integration with Cloud and IoT Platforms: The system can be enhanced by integrating it with cloud servers, enabling real-time data storage, remote monitoring, and advanced data analytics through IoT platforms.
- 2) AI-Based Predictive Maintenance: Machine learning and artificial intelligence algorithms can be implemented to analyse historical crack data and predict potential track failures before they occur, thereby improving preventive maintenance strategies.
- 3) Addition of Live Video Surveillance: A camera module can be incorporated to capture real-time images or video footage of track conditions, allowing remote visual inspection and improved fault verification.
- 4) Solar-Powered System Enhancement: The integration of solar panels can make the system more energy-efficient and capable of long-term autonomous operation, particularly in remote and off-grid railway sections.
- 5) Multi-Track Compatibility and Automatic Switching: The system design can be upgraded to support multiple track gauges with automatic track switching and navigation capabilities.
- 6) Obstacle Classification and Intelligent Response: Future versions of the system can classify detected obstacles such as debris, animals, or human presence and trigger appropriate automated safety responses or alerts.
- 7) Wireless Communication Upgrade (4G/5G or Lora WAN): Upgrading the communication module from GSM to advanced technologies such as 4G, 5G, or Lora WAN can provide faster, more reliable data transmission and better integration with national railway safety networks.
- 8) Proposed Railway Track Monitoring System (Prototype)

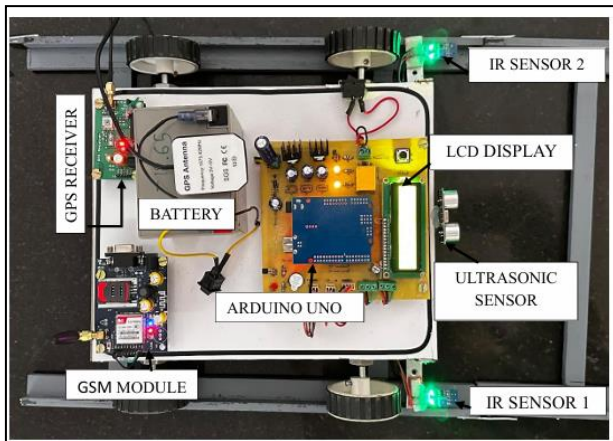


Fig. 3: Proposed Railway Track Monitoring System (Prototype)

#### 9) Railway Track Accident Incidents



Fig. 4: Railway Track Accident Incidents

- 1) Rail fracture disrupted Mumbai local train services: A rail fracture on the Central Railway line between Vikhroli and Kanjurmarg caused brief disruption of local trains.
- 2) Track fracture near Arakkonam (Chennai): A rail fracture near Arakkonam affected MEMU passenger train services, highlighting danger from track defects.
- 3) Patna–Indore Express derailment linked to rail fracture: Poor track maintenance and suspected rail fracture were being investigated as causes in the derailment of the Patna–Indore Express.
- 4) Derailment near Cuttack linked to suspected track defect: The Bengaluru–Kamakhya AC Express derailed near Cuttack, reportedly due to a suspected track defect during maintenance work, resulting in one death and over 30 injuries.
- 5) Patna–Indore Express derailment due to fractured track (Kanpur Dehat.) Investigations indicated that a track fracture was likely the cause of the severe derailment of 14 coaches, causing many casualties.

#### VIII. CONCLUSION

The smart railway track monitoring system using GSM and GPS provides an efficient and reliable solution for detecting cracks and obstacles on railway tracks in real time. By

integrating sensors, GPS tracking, and GSM communication, the system ensures timely alerts to railway authorities, enhancing passenger and cargo safety. It reduces reliance on manual inspections, saving time, effort, and maintenance costs, while enabling continuous monitoring even in remote areas. Its compact, scalable, and cost-effective design makes it suitable for widespread deployment across India's railway network. Overall, this project represents a significant step toward modernizing railway safety, preventing accidents, and supporting the development of a smarter, safer, and more efficient railway infrastructure.

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