Gargie Tiwari, 2024, 12:3
ISSN (Online): 2348-4098
ISSN (Print): 2395-4752

International Journal of Science, Engineering and Technology

An Open Access Journal

# Track Break Detection: Protecting One of the Largest Means of Transport from Catastrophe

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**Abstract- Rail transportation is a cornerstone of India's infrastructure, boasting one of the world's largest railway networks. Despite its growth, the Indian rail system grapples with persistent challenges such as unsafe crossings, fire hazards, and unmonitored track conditions leading to accidents and derailments. Seasonal fluctuations cause tracks to expand and contract, potentially resulting in track cracks. To address these issues, a proposed system employs sensors to detect and track obstacles and cracks, sending alerts to control rooms via SMS using GSM and GPS modules. Railway transportation is pivotal for global mobility and logistics. Consequently, the development of advanced track brake systems is imperative. Traditional braking systems suffer from friction-related issues, including wear, heat, and reduced performance in adverse weather. Advanced track brake systems leverage innovative technologies and materials to overcome these challenges. In conclusion, the adoption of advanced track brake systems signifies a significant advancement in enhancing railway safety, efficiency, and sustainability. Incorporating electromagnetic and regenerative braking, sensor technologies, and adaptive algorithms, these systems offer a comprehensive solution to meet the evolving demands of modern railways. Continued research and investment are vital for further improving railway safety and performance worldwide.**

**Keywords- railway maintenance, GPS Module; Arduino Microcontroller; Railway Track**

## I. INTRODUCTION

Railways serve as the lifeblood of a nation, particularly in developing countries, catering to public transportation needs and facilitating trade and supply chains. The railway industry has evolved, offering improved opportunities for both the public and the economy. With rail being one of the most energy-efficient modes of transportation, it accounts for 8% and 9% of global passenger and freight transit, respectively, while consuming only 3% of total transportation energy. Compared to private automobiles and airlines, rail uses 12 times less energy and emits 711 times fewer Greenhouse Gas (GHGs) per passenger kilometer traveled, making it the most efficient means of motorized passenger transportation. Freight rail, besides shipping, is also highly energy-efficient and low carbon. However, ensuring high-performance railway operations is crucial for the continuous running of trains and passenger safety. Daily commuters, tourists, and the general public rely on trains, and their safety is jeopardized if railway tracks are not fit for operation. Similarly, ensuring the safety and reliability of freight transportation is vital for the supply chain, requiring fault-free and fault-tolerant railway rails. Regular inspections are essential to mitigate incidents like train derailments

caused by mechanical and physical wear and tear over time. Internationally, rail freight traffic surged between 2018 and 2019, with Europe and Turkey handling approximately 3.1 trillion-ton kilometers of freight in 2019, slightly lower than Asia/Oceania/Middle East, which managed over 3.5 trillion-ton kilometers of freight. Notably, China and India each service roughly 772.8 and 770 billion passenger kilometers annually, respectively, with other nations like Russia, France, Germany, Ukraine, and the United Kingdom also experiencing significant passenger traffic. Pakistan is another country where rail travel is preferred, with an estimated 70 million people reported to have traveled by train between 2018 and 2019. Pakistan Railways (PR) generated 48.652 billion from its operations between 2020 and 2021. Despite its popularity, the railway system in Pakistan falls short of global standards in many aspects. Issues such as cracks, creep, loose fittings, crash sleepers, ballast, discontinuity, missing nuts and bolts, and wheel burns persist due to insufficient maintenance, delayed problem detection, and preemptive inspections. This raises serious concerns about the safety of rail transit operations in Pakistan, leading to numerous severe incidents resulting in significant human and financial losses. According to PR's yearly reports, between 2013 and 2020, 127 incidents occurred due to derailments and track defects.

## II. ABOUT TRACK DETECTION SYSTEM TECHNOLOGY

Track break detection system technology refers to the use of various sensors, modules, and algorithms to identify cracks or breaks in railway tracks. These systems are essential for ensuring the safety and reliability of railway transportation networks. Here's an overview of the key components and technologies involved in track break detection systems:

**Sensors**

Ultrasonic sensors, laser sensors, and infrared sensors are commonly used to detect anomalies in railway tracks. Ultrasonic sensors emit high-frequency sound waves that bounce off the track surface and detect changes caused by cracks or breaks. Laser sensors use laser beams to measure surface irregularities, while infrared sensors detect temperature variations that may indicate structural weaknesses.

**2. Data Processing**

Once sensor data is collected, it is processed using algorithms to analyze and identify potential track breaks. Machine learning algorithms can also be used to train models for detecting patterns associated with track breaks.

**3. Communication Modules**

GPS modules and GSM modules are often integrated into track break detection systems to provide real-time location tracking and remote monitoring capabilities. GPS modules determine the precise location of the track segment being monitored, while GSM modules enable communication with central control rooms or maintenance teams via SMS or data transmission.

**4. Control Systems**

Control systems are responsible for managing sensor data, triggering alerts in case of track break detection, and coordinating maintenance activities. These systems may be implemented using micro controllers such as Arduino or Raspberry Pi, which can interface with sensors and communication modules to automate detection and response processes.

**5. Integration with Maintenance Systems**

Track break detection systems are typically integrated with existing railway maintenance systems to facilitate timely repairs and preventive maintenance.

Integration with maintenance management software allows maintenance crews to receive alerts, prioritize repairs, and track the status of maintenance activities in real time. Overall, track break detection system technology plays a crucial role in ensuring the safety, reliability, and efficiency of railway transportation networks by detecting and addressing track defects before they lead to accidents or service disruptions.

## III. PROPOSED SYSTEM

The proposed framework overcomes the limitations of existing systems used for detecting track defects. Our project employs sensors and an Arduino microcontroller to identify breaks in the tracks, measuring the distance between the two rails. We utilize an ultrasonic sensor for this purpose, which measures the distance between the tracks. If a break occurs in the track, the longitude and latitude coordinates of the location are transmitted to the nearest station or control room. The ultrasonic sensor continuously monitors the distance between the tracks, and any slight deviation triggers the transmission of a message containing the coordinates to the nearest station or control center using GPS and GSM modules. This project aims to revolutionize the approach to track defect detection in railways.

## IV. LITERATURE SURVEY

The Indian railway system stands as one of the busiest in the world, encompassing a track network spanning 127,000 sq. km. Nearly two-thirds of the population relies on this extensive railway network in India. However, approximately 60% of accidents occur at railway track crossings or due to breaks in the tracks, resulting in loss of life and economic impact. Addressing this issue is of paramount importance, and existing systems employed by railways to tackle this challenge warrant attention. Currently, manual inspection and maintenance of tracks are conducted by personnel, alongside the utilization of systems such as the SPURT Car and USFD manual machine for break detection and monitoring. While both methods involve surveying and identifying breaks, they rely heavily on human intervention for track monitoring. Moreover, these methods are limited to specific routes and may not cover all railway divisions comprehensively. In response, our project proposes a railroad break detection system utilizing Arduino UNO R3 and sensors to detect breaks, with GPS modules providing location data and GSM modules sending alerts via messages. Our endeavor is dedicated to crafting a solution that not only addresses the break detection issue but also ensures higher precision and accuracy compared to existing systems. Additionally, our project aims to enhance railway safety, an aspect where current systems fall short.

**Parts of the System**

**Arduino Nano R3**

The Arduino Nano, introduced in 2008, is a compact and versatile board based on the ATmega328P microcontroller. It mirrors the connectivity and specifications of the Arduino Uno but comes in a smaller form factor, making it suitable for use on breadboards. Featuring 30 male I/O headers arranged in a DIP-30 format, the Arduino Nano can be easily programmed using the Arduino Software, which is a part of the integrated development environment (IDE) common to all Arduino boards.


Figure 1: arduino nano R3

This IDE is accessible both online and offline, providing a user-friendly platform for coding and development.

**ML293D Motor Driver**

The L293D is a standard motor driver integrated circuit (IC) that facilitates the operation of DC motors in either direction. With its 16-pin configuration, the L293D can control a pair of DC motors simultaneously, allowing movement in both forward and reverse directions. This means that a single L293D IC can effectively manage the operation of two DC motors.

Figure 2: ML293D motor driver

**GSM Module (900A)**

This ultra-compact and reliable wireless module, the SIM900A, offers a comprehensive Dual-band GSM/GPRS solution in a surface-mount technology (SMT) module, ideal for integration into various customer applications due to its small dimensions. With an industry- standard interface, the SIM900A ensures GSM/GPRS 900/1800MHz performance for voice, SMS, data, and fax communications, all within a compact form factor and with low power consumption.


Figure 3: GSM module (900a)

**Ultrasonic Sensor**

Figure 4: Ultrasonic sensor

An ultrasonic sensor is an electronic device designed to measure the distance of an object by emitting ultrasonic sound waves and converting the reflected sound into an electrical signal. These ultrasonic waves travel faster than audible sound, which humans can hear. Typically, ultrasonic sensors consist of two main components: the transmitter, which emits the sound using piezoelectric crystals, and the receiver, which detects the sound after it has traveled to and from the target. Primarily used as proximity sensors, ultrasonic sensors find applications in various fields. They are commonly employed in vehicle self-parking technology and collision avoidance systems. Additionally, ultrasonic sensors are integral to automated obstacle detection systems and manufacturing technology. In comparison to infrared (IR) sensors used in proximity sensing, ultrasonic sensors are less susceptible to interference from smoke, gas, and other airborne particles, although environmental factors like heat can still affect their performance. The frequency range of ultrasonic waves is above 20 kHz. These are mainly used in measuring distance applications. The following image indicates the ultrasonic transducer

**GPS Module**

The NEO-6MV2 serves as a GPS (Global Positioning System) module primarily utilized for navigation purposes. This module accurately determines its position on Earth and provides output data consisting of longitude and latitude low power consumption, and flexible memory options, are particularly well-suited for battery-operated mobile devices with stringent cost and space constraints. Thanks to its innovative design, the NEO-6MV2 delivers exceptional navigation performance even under challenging conditions.


Figure 5: GPS module

**LCD Display**

LCD stands for Liquid Crystal Display, which is a type of electronic display module used in a wide range of applications including various circuits and devices such as smart phones, calculators, computers, TV sets, and more. These displays are particularly favored for their versatility in displaying

multi- segment light-emitting diodes and seven-segment characters. The main advantages of using LCD modules include their affordability, programmability, ability to display animations, and the flexibility to showcase custom characters without limitations.

Figure 6: LCD display

**Algorithm**

- The program algorithm operates as follows:
- The motor initiates and the Ultrasonic sensor is activated. The motor propels the vehicle forward.
- Continuously, the ultrasonic sensor scans the tracks. Upon detecting a crack, the vehicle halts.
- Subsequently, the GPS retrieves the coordinates of the location. Using the GSM module, a specific message such as "Obstacle Present" is sent to the registered number.
- Once both messages are sent, the program resets to its initial stage. The motor restarts, and the track is scanned once more.

## V. RESULT

As we've discovered, existing systems are both time-consuming and economically inefficient. The proposed system addresses these shortcomings while also enhancing accuracy and crack identification along railway tracks. This solution stands out as the most efficient means to improve the performance of our country's rail routes and minimize the occurrence of accidents. By doing so, it not only safeguards the lives of passengers and prevents economic losses but also saves valuable time and resources in crack detection.

## VI. CONCLUSION

Here, the proposed module consists of the hardware components described earlier in the system design hardware description.

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