**Smart Railway Track Condition Monitoring**

**Team ID: 15**

**Members: Anagha Prajapati, Arushi Shukla, Navneet Kumar Gupta**

**Introduction**

Railway track failures pose severe risks, including derailments, costly repairs, and service disruptions. So, early detection of track faults, such as cracks, gaps, and damage, is vital for ensuring the safety and efficiency of railway operations. In Indian Railways, however, current rail inspection methods often rely on costly, manual systems that lack smart technology, limiting the frequency as well as accuracy of checks. The frequency is the problem we want to capitalize on. This project aims to make a smart, low- cost IoT-based monitoring system, which requires less manual intervention. We want to bring the frequency of checks to once a week, or even 3 days.

**Scope**

Given the time constraints and available resources, we are keeping the scope of the project very limited. This won’t be a full-fledged solution; instead, it will serve as a proof of concept. Some parts of the system can be used as they are, while others can be improved to create a complete, fully functional project. Our focus will be on accurately sensing and analysing trackdata and ensuring this data is accessible on server nodes. This will validate the practicality of using IoT for ongoing track monitoring, paving the way for a more advanced and fully deployable solution. So, as we explain the proposal further, we will mention what further should be done to realize the full potential of the project.

**The project**

We want to make a trolley vehicle model. The trolley, which can be manually pulled along a tabletop track model, is equipped with an IoT system with an array of sensors. These sensors gather real-time data on track conditions, such as cracks, obstructions, or misalignments. The collected data is processed by a microcontroller and transmitted to a cloud platform for analysis.

The actual system should be a motorized and autonomous, but to limit the scope we are just making a trolley vehicle which can be pulled.

**Project’s Objectives**

* Detecting railway track faults, such as cracks, gaps, and damage using sensor arrays.
* Providing real-time and online condition updates and triggering alerts when critical issues arise.
* Simulating a cost-effective, tabletop model to collect and analyse data for understanding and monitoring track conditions.

**Deliverables**

* A functional tabletop IoT model for railway track monitoring.
* Real-time data collection and visualization through a cloud platform (e.g., Thing Speak or OM2M).
* Alerts and insights triggered based on sensor thresholds.

**Hardware Requirements**

**Note:** We are just listing all the hardware requirements for the project, but we are not expecting that we will get every component from the lab faculty. We can manage without some hardware by adapting our design and focusing on the core functionalities. Additionally, we can get certain components from other sources if necessary.

1. **Ultrasonic Sensors (HC-SR04) (Quantity- 2)**

These sensors will be mounted on the trolley to face the simulated track. As the trolley moves, the ultrasonic sensors will continuously emit sound waves and measure the time it takes for the echo to return. Cracks or gaps in the track will disrupt this echo, causing variations in the distance measurements. These variations will help identify structural anomalies in the track.

Store links:

<https://robu.in/product/hc-sr04-ultrasonic-range-finder/>

1. **IR Sensors (KY-033 or TCRT5000) (Quantity- 2)**

The IR sensors will be positioned on the trolley to scan the surface of the track for obstacles. By detecting infrared reflections, they will sense any debris or other objects on the track that could interfere with normal operations.

Store links:

<https://robu.in/product/tcrt5000-single-channel-line-tracking-sensor-module/?gad_source=4&gclid=EAIaIQobChMImZyA85v6iwMVuRuDAx2VoRyQEAQYASABEgKJlfD_BwE>

1. **Vibration Sensors/Accelerometer (ADXL345 MEMS/SW-420/Piezo-vibration-sensor) (Quantity- 1)**

This sensor will be fixed on the trolley to measure vibrations caused by its movement over the track. Sudden changes in vibration intensity or frequency will indicate anomalies such as track misalignment or structural damage. The sensor's data will be processed to monitor track stability.

Store links:

<https://robu.in/product/vibration-sensor-module-alarm-motion-sensor-module-vibration-switch-sw-420/>

<https://robu.in/product/adxl345-digital-angle-acceleration-sensor-module/>

<https://robu.in/product/grove-piezo-vibration-sensor/?gQT=1>

<https://www.amazon.in/dp/B0BHWDMBBB?ref=cm_sw_r_cp_ud_dp_10N1KCEA3VDVKFNBWRG2&ref_=cm_sw_r_cp_ud_dp_10N1KCEA3VDVKFNBWRG2&social_share=cm_sw_r_cp_ud_dp_10N1KCEA3VDVKFNBWRG2&_encoding=UTF8&psc=1>

1. **Temperature Sensor (DHT11 or LM35) (Quantity- 1) (Optional)**

The temperature sensor will record environmental temperatures along the track model. Abnormal temperature readings could indicate thermal stress on the track, such as expansion or contraction, which might compromise its integrity.

Store links:

<https://robu.in/product/lm35-to-92-3-board-mount-temperature-sensors/?gad_source=1&gclid=Cj0KCQiAz6q-BhCfARIsAOezPxlaEp4BbqBcIjt-XVHnzump5HuCwRTJ8WKswyVDMRGggx4x1NnDqxAaApw_EALw_wcB>

1. **Microcontroller (ESP32) (Quantity- 1)**

The ESP32 will serve as the central processing unit for the system. It will gather data from all the sensors, process the readings, and transmit the results to a cloud platform such as Thing Speak or OM2M for real-time monitoring and analysis.

Store links:

1. **Power Supply (Quantity- 1)**

This portable battery will power the ESP32 and all the sensors, ensuring that the system can operate independently and continuously during testing.

Store links:

<https://electronicspices.com/product/1800mah-3-7v-18650-li-ion-lithium-rechargeable-cell-battery-pack-of-1pcs?srsltid=AfmBOorGfNka78rEmzlWxvpyOXLQCrLR5ov28aj5tUGILSTL2rANbnfTZ2Y&gQT=1>

<https://robu.in/product/dmegc-inr18650-26e-3-7v-2600mah-li-ion-battery/>

<https://robu.in/product/panasonic-cr2016-3v-lithium-coin-battery/>

1. **Prototype Track Model (Custom-Made)**

The track model will be designed to replicate a small segment of railway tracks. Anomalies such as gaps, loose sections, or debris will be introduced for testing purposes. The sensors on the trolley will interact with this model to demonstrate their functionality.

1. **Prototype Trolley Model (Custom-Made)**

The trolley will require a sturdy platform, four lightweight wheels on axles with bearings and mounts which will position the sensors for accurate data collection, ensuring easy manual movement for testing and demonstration.

**Data Collection Plan**

Sensors will collect real-time data from the tabletop track model during controlled tests. These tests will simulate various fault scenarios, such as cracks, gaps, and obstructions, to assess the sensor responses. Data parameters will include vibration levels, temperature variations, and obstruction signals. A microcontroller like ESP32 or Arduino will process the collected data and transmit it to a cloud platform for further analysis.

Expected Outcomes:

* Analyse vibration patterns and temperature changes and other sensors’ data to validate sensor accuracy and functionality.
* Develop an understanding of normal vs. abnormal vibration patterns to improve fault detection reliability.
* Over time, we aim to establish a baseline by distinguishing normal vibration patterns caused by regular movement from irregular vibrations indicative of anomalies or structural damage

**Conclusion**

This project proposes a cost-effective IoT-based solution for railway track condition monitoring using commonly available sensors and microcontrollers. By simulating real-world conditions on a tabletop model, it aims to demonstrate the feasibility of detecting faults and transmitting alerts in real time. The system's objectives include ensuring safety, reducing risks, and improving track maintenance through predictive monitoring.

**References**

<https://content.iospress.com/articles/international-journal-of-rf-technologies/rft190210?form=MG0AV3>

<https://www.oaijse.com/VolumeArticles/FullTextPDF/190_16.IoT_BASED_RAILWAY_TRACK_MONITORING_SYSTEM_USING_ULTRASONIC_SENSOR.pdf?form=MG0AV3>

<https://ijcrt.org/papers/IJCRT2304780.pdf>