SMART INDIA HACKATHON 2024

PROJECT INFORMATION

- **Problem Statement ID**: 1584
- **Problem Statement Title:** AI based acoustic wave monitoring of rail defects like cracks, fracture and prediction for rail wear, quality along with other parameter.
- **Theme:** Transportation & Logistics
- **Category:** Hardware
- **Team ID:**
- **Team Name:** TopCoders

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RAILWAY TRACK DEFECT DETECTION SYSTEM

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Solution/Idea:

Implementation of a **Geo-Locating Dual Cross Verifying Railway Track Defect Detection System** using **Microphones** and **Ultrasonic Transmitters & Receivers**.

- **Noise-canceling** microphone system detects defects in the tracks.
- **Ultrasonic Transmitters & Receivers** detects defects and cross verifies it.
- Anomalies detected are Geo-marked onto maps using **GPS-Module (NEO-6M)**.
- Preprocessing and Storage are carried out through a **Raspberry Pi 5** and **storage system** respectively.
- Data is uploaded onto the cloud using **Wi-Fi 5.0** or **4G/LTE.**
- Cloud data will be processed by the AI model deployed on **AWS/GCP/Azure**.

Problem Resolution:

- AI Based **Railway Track Defect Detection System** provides highly accurate, geo-marked defect data collected from moving locomotives that is **easily accessible** for repairing purposes.
- Removes the need of physical conquests that are set out to find defects in the railway tracks. **Increases time and efficiency** of the repairmen of tracks. **Promotes safety** and regular track upkeep for smooth functioning.

Unique Value Proposition (UVP):

- **Dual Cross Verification** of the defects detected.
- Data is uploaded automatically onto the cloud using Wi-Fi.
- **AI integration** on the cloud for seamless defect detection.
- Defects are **geographically marked** for ease.
- Data is **encrypted** and accessible to select individuals only through application and website.
- Measures are taken to keep operating **costs to a minimum**.

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TECHNICAL APPROACH

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Application Development:

React Native Framework with HTML,CSS & JavaScript.
Android Studio for Emulator

Website Development:

Vite JS and React framework for frontend
Express(Node.js web application framework) for backend

Machine Learning Frameworks

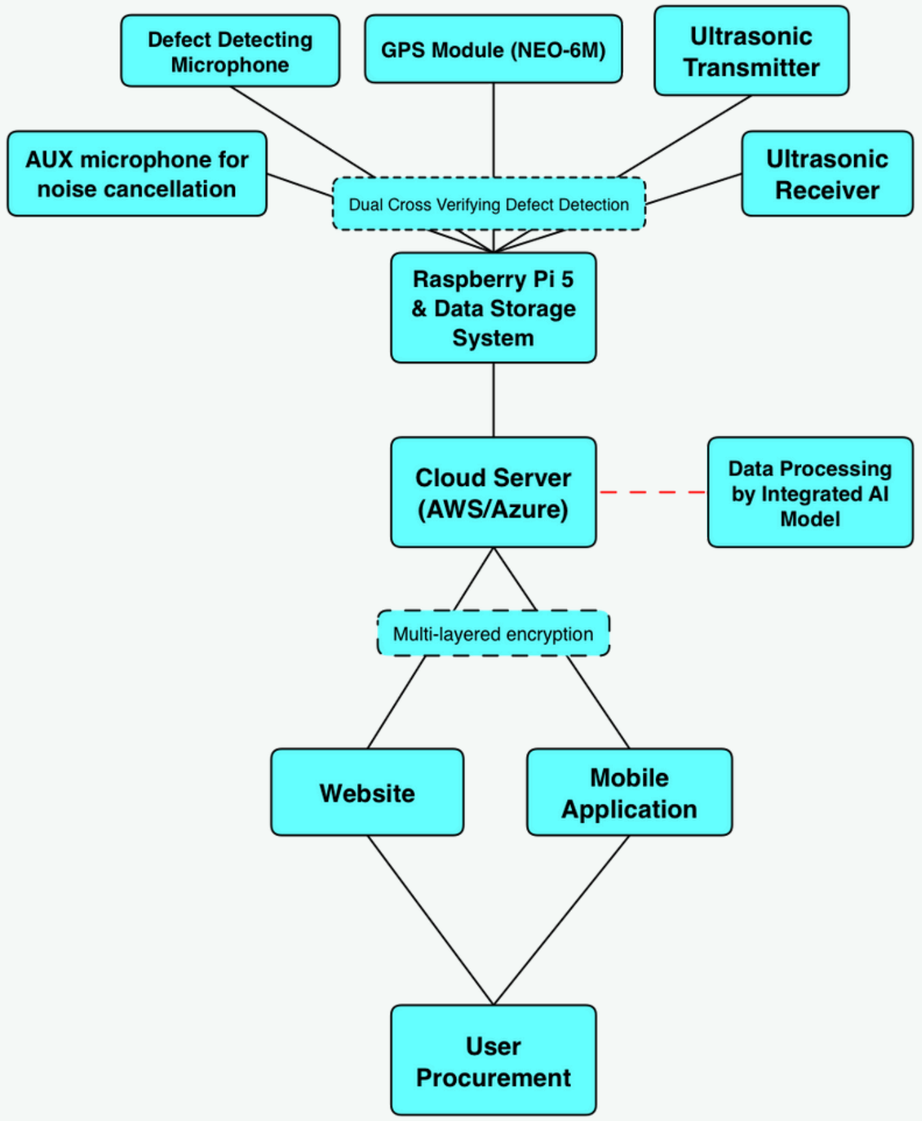
Logistic regression, Librosa library, random forest and decision tree AWS, Elastic beanstock, flash (for deployment)

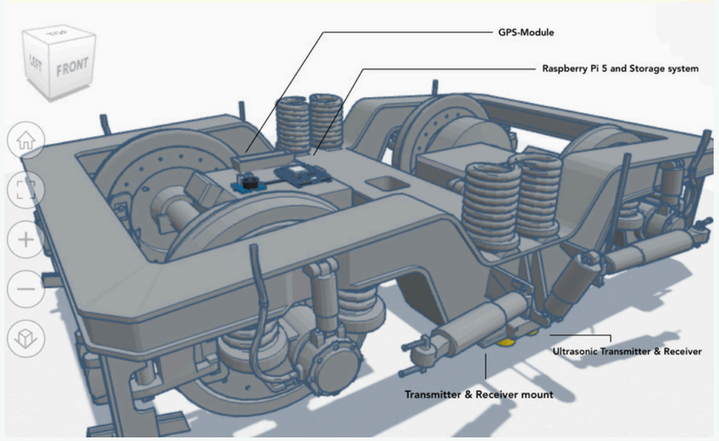
Hardware:

AWS IOT Core, AWS Lambda, AWS SNS, AWS Dynamo DB, Raspberry Pi 5,
INMP 441, NEO 6M module (GPS), Ultrasonic Transmitter & Receiver, NC Mic (Shure SM7B), Defect Detecting mic (Senheiser MKE 600)

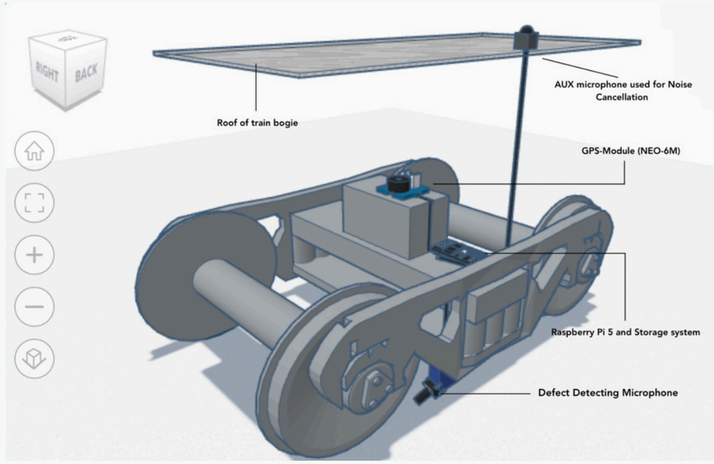
Cloud Services:

AWS Cloud services





(a) 3D illustration of ultrasonic transmitter and receiver defect detection system on stripped bogie's wheel base



(b) 3D illustration of Microphone based defect detection system on stripped bogie's wheel base

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FEASIBILITY AND VIABILITY

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Feasibility

Technical Feasibility

All the components that are required for the construction are *readily available* in the market and can be integrated into the system. Though some level of expertise if required initially, once the apparatus is set up, the maintenance crew *can access information easily.*

Financial Feasibility

The complete installation of the apparatus requires a one time capital of *₹1,15,000-₹1,75,000 (approx.)* for the instruments, devices and installation.

Operational Feasibility

Damage control measures and regular maintenance help *reduce long-term costs*.
Cloud services incur costs of *₹5,000-₹10,000 monthly*.
Damage to equipment is considered as a variable cost.

Market Demand

There is *significant demand* for the following defect detection system within the Indian Railways as it *offers a competitive solution* when compared to the various international railway track defect detection systems around the world.

Overcoming Challenges

Dealing with damage caused to the equipment and instrumentation

Sturdy installation along with metal guards to protect the transmitter, receiver and microphone from any oncoming debris without hampering defect detection.

Undesirable noise intake from defect detecting microphone

Additional AUX-microphone installed on roof of the bogie for Noise-Cancellation purposes.

False reading inferred in defect detection procedure

Use of dual cross verification of defects from two independent systems

Manual marking of defects on map

Integrated AI model on cloud that detects defects and geo-marks them using GPS-module.

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IMPACT AND BENEFITS

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Impact on target audience

Positive Impacts:

Improvement in Safety: Automated, real-time defect detection *significantly improves* railway safety.

Economical: The system reduces the cost of manual inspections and track maintenance, *offering long-term savings*.

Social Benefits: Safer railway tracks enhance *public trust*, ensuring *more reliable transport* for millions of people.

Negative Impacts:

High Initial Costs: The upfront investment in hardware, AI, and cloud infrastructure may seem high. Though, once set up, the system will give a *great return on investment* over time.

Benefits of solution

Social Benefits:

Improved Access: *Safer* and more comfortable journeys.
Empowerment: Empowers railways with *data-driven decisions*, enhancing the ability to preemptively maintain infrastructure.
Reduction in Accidents: *Significant reduction* in accidents caused by faulty tracks.

Economic Benefits:

Increased Productivity: Automation of inspections and real-time monitoring leads to more *efficient track maintenance.*
Cost Reduction: Reduces *long-term manual inspection costs* and *minimizes train delays* due to maintenance. .

Environmental Benefits:

Energy Efficiency: Efficient monitoring *reduces the need for manual inspections*, which helps in cutting costs.
Waste Reduction: Reduces infrastructure wear and tear by *identifying defects early*, thereby lowering resource waste.
Sustainable Maintenance: *Optimizes maintenance schedules*, ensuring less frequent and more targeted interventions.

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RESEARCH AND REFRENCES

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1. ScienceDirect. Ultrasonic-based Structural Health Monitoring Systems. Available at: https://www.sciencedirect.com/science/article/pii/S026322412300596

2. ScienceDirect. Ultrasonic and Vibration-Based Defect Detection Methods. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0263224123005961

3. MDPI Electronics. Anomaly Detection in Large-scale Graphs with GCNs and DBSCAN. Available at: https://www.mdpi.com/2079-9292/13/13/2625

4. IEEE Xplore. Fault Detection Systems Using Acoustic Emissions. Available at: https://ieeexplore.ieee.org/iel7/6287639/9668973/09904575.pdf

5. Springer Link. A Comprehensive Survey of Defect Detection Methods Based on Signal Processing and Machine Learning. Available at: https://link.springer.com/article/10.1007/s11277-022-09992-5