Acoustic Sensor Based Rail Road Defect Detection

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Abstract

This project proposes a cost-effective and reliable rail defect detection system that utilizes acoustic wave technology to identify cracks, fractures, and surface wear in real time. The solution integrates IoT-enabled acoustic sensors with an ESP32 microcontroller and LoRaWAN communication to provide continuous monitoring of railway tracks. By transmitting data wirelessly over long distances, the system enables early detection of defects and supports predictive maintenance practices. Designed to be scalable and robust in harsh outdoor environments, the proposed approach enhances railway safety, reduces the need for manual inspections, and lowers overall maintenance costs.

Keywords: Rail defect detection, Acoustic sensors, IoT, ESP32, LoRaWAN.

Contents

Introduction

- **Purpose:** Enhance railway safety and efficiency by detecting and predicting rail defects early for proactive maintenance, reducing accidents, downtime, and costs.
- **Technologies Used:** Acoustic sensors (piezoelectric & ultrasonic),ESP32 microcontroller,LoRaWAN communication, edge computing.
- **Problem Addressed:** Manual inspections are slow, error-prone, and resource-intensive, while hidden rail defects compromise safety and lack real-time predictive capabilities.
- **Goal:** Create a real-time rail defect detection and prediction system to improve safety, prevent disruptions, and enable cost-effective, proactive maintenance.
- **Outcome:** Real-time defect detection and prediction, reduced inspection costs and downtime, lower carbon emissions, improved sustainability, and a new benchmark for transportation safety using IoT and edge computing.

Literature Survey

No	Title	Author	Journal Name & Year	Methodology Adapted	Key Findings	Gaps
1.	Acoustic Emission Techniques for Rail Crack Detection	S. Smith, R. Brown	International Journal of Railway Science, 2020	Acoustic sensors & signal processing	Early detection of micro-cracks.	Sensitive to environmental noise.
2	IoT and LoRaWAN for Intelligent Railway Monitoring	Y. Zhang, L. Li	IEEE Internet of Things Journal, 2021	IoT sensors + LoRaWAN communication	Enabled real-time remote monitoring.	Scalability issues with large data.
3	Machine Learning Approaches for Railway Track Fault Detection	P. Kumar, S. Reddy	IEEE Access, 2022	Deep Learning (CNN and RNN models)	Improved detection accuracy.	Needs large datasets & high computation..

Proposed System

- **Acoustic Sensors** – Mounted on the railway track to capture sound and vibration patterns, which change when cracks, fractures, or wear occur.
- **ESP32 Microcontroller** – Collects and processes the acoustic signals at the edge, reducing delay and improving real-time monitoring.
- **LoRaWAN Communication** – Ensures long-range, low-power data transmission, making the system suitable for remote railway networks.
- **Real-Time Monitoring** – Provides early warnings of defects, supporting predictive maintenance and reducing chances of sudden failures.
- **Cost-Effective and Scalable** – The system can be expanded across large railway networks while lowering inspection costs and downtime.

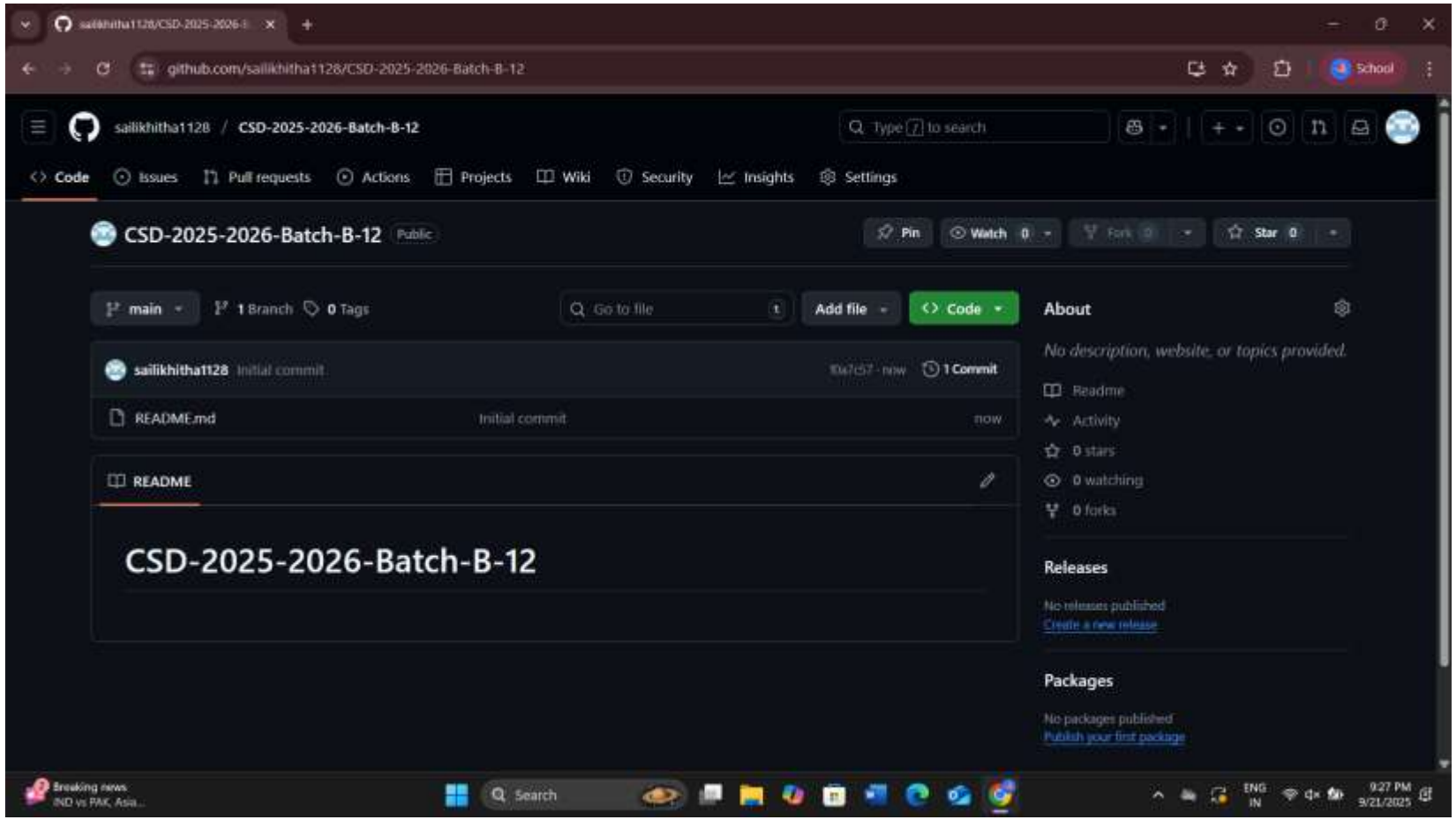
Reference

[1]. A. Murad and J. Pyun, “Deep Recurrent Neural Networks for Human Activity Recognition,” *Sensors*, vol. 17, no. 11, pp. 2556-2565, Nov. 2017.

[2]. S. Smith and R. Brown, “Acoustic Emission Techniques for Rail Crack Detection,” *International Journal of Railway Science*, vol. 8, no. 2, pp. 45-52, Jan. 2020.

[3]. Y. Zhang and L. Li, “IoT and LoRaWAN for Intelligent Railway Monitoring,” *IEEE Internet of Things Journal*, vol. 9, no. 5, pp. 4112-4120, Mar. 2021.

Git Hub Dashboards of each student



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Any Queries?

Thank You!!!