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TITLE PAGE

- **Problem Statement ID –SIH1584**
- **Problem Statement Title-**

  AI-based Acoustic Wave Monitoring System For Real Time Rail Defect Detection And Prediction
- **Theme-transportation and logistic**
- **PS Category- Software/Hardware**
- **Team ID-**
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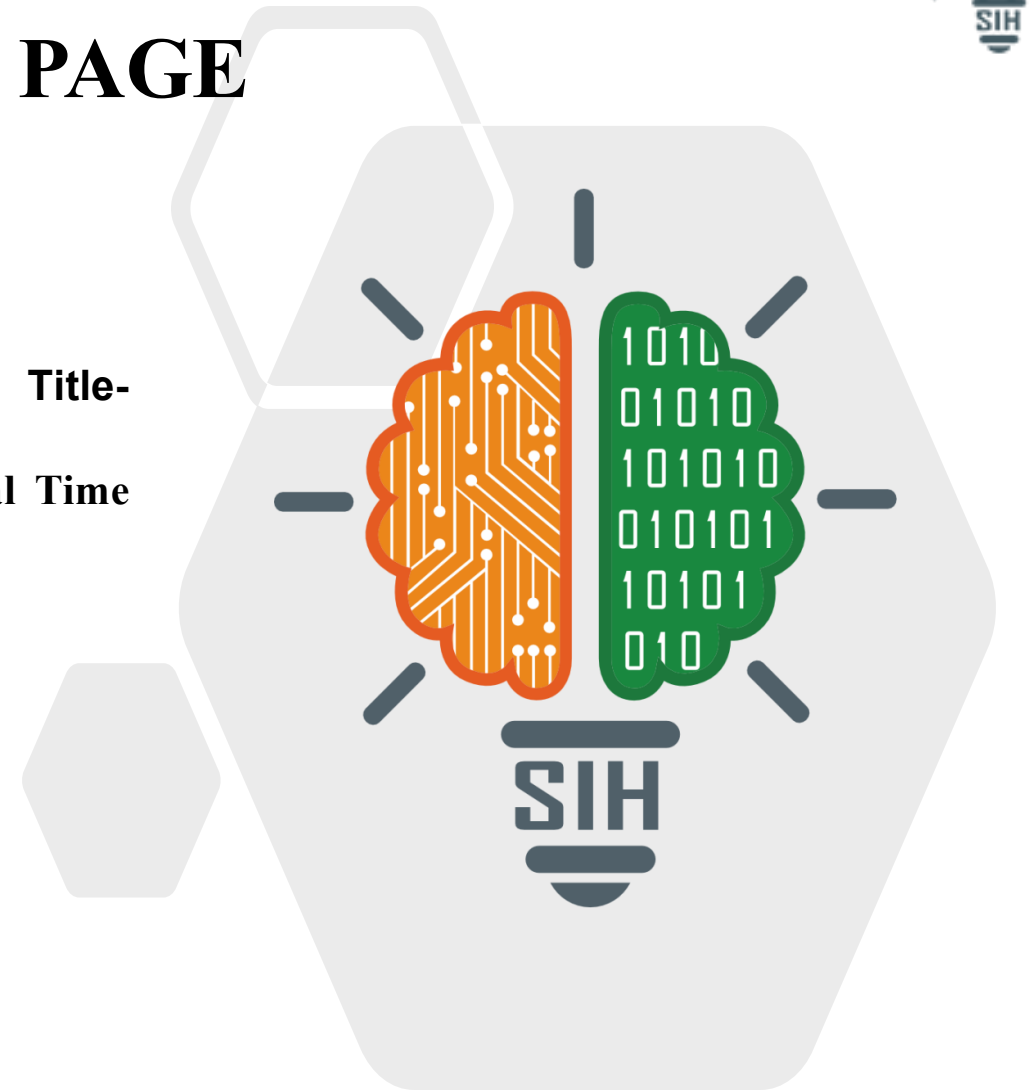

AI-based Acoustic Wave Monitoring System For Real Time Rail Defect Detection And Prediction

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❖ AI-Based Acoustic wave monitoring system for real time rail defect detection and prediction

- Rail track failures cause accidents, delays, high maintenance costs manual inspection is slow error prone and unsafe as well and traditional NDT(ultrasonic and visual) is costly and limited in real time detection so we proposed an AI based Acoustic wave monitoring system for real time defect detection and prediction
- The AI based monitoring system for rail defect detection detects cracks ,fractures and wear in real time using sensors and ML predictive analytics to forecast rail degradation and maintenance needs

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TECHNICAL APPROACH

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- Since its mainly hardware based we are using microphonemodule,LEDs,Buzzer,Breadboard,JumperWire set,resistor pack,USB-C cable,Power bank and 1 Aurdino UNO R4 Wi-Fi and for coding we using C language

- Step 1: Hardware Initialization Initialize Arduino UNO R4 Wi-Fi. Configure I2S microphone pins. Set up GPIO pins for: Green LED → Normal Red LED → Defect Buzzer → Defect alarm
- Step 2: Data Collection & Preprocessing (Edge Impulse setup)Record audio samples for: Class A: Normal rail sound Class B: Defect rail sound (scratches, cracks, metal impact).Segment data into windows (1000 ms length, 500 ms stride).Apply MFCC feature extraction to each window.
- Step 3: Model Training (in Edge Impulse)Build a classification neural network: Input: MFCC features Output: {Normal, Defect}Train until accuracy ≥80%.Validate with live classification.
- Step 4: Deployment Export trained model as Arduino Library .Import library into Arduino IDE. Upload sketch to Arduino R4 Wi-Fi
- Step 5: Real-Time Monitoring Algorithm (on Arduino)
- Step 6: Demo & AlertsPlay test audio → Arduino classifies → triggers appropriate LED/Buzzer Judges see a clear link: Rail sound → ML model → Safety alert.

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FEASIBILITY AND VIABILITY

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- Risk assessment and mitigation
- 1. sensor callibration issues- use redundancy and self calibration algorithms
- 2. False positive/negatives-improve ML accuracy with large datasets
- 3. Data transmission failures-Use edge computing + cloud backup
- Challenges: Noisy environment
- Solution: Signal Processing + Noise cancelling
- Challenge: Real time processing speed
- Solution: Optimize models with edge AI inference
- Challenge : Large Scale Deployment cost
- Solution: Start with critical rail sections, Scale Gradually

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IMPACT AND BENEFITS

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- Safety Enhancement : Proactive detection of cracks and fractures prevents derailments send accidents
- Operational Efficiency: Continuous monitoring reduces the need for frequent manual inspections
- Real time acoustic sensing: Continuous detection of structural anomalies without Halting Rail services
- Passenger Safety : Increases public trust in rail support

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RESEARCH AND REFERENCES

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- https://youtu.be/4nkY9oUhg9E?si=vRH-q35nVQxEDsCn
- https://youtu.be/tS6xEeSvjz8?si=zkBNSopFXhQMiT4w