SMART RAILWAY MONITORING SYSTEM REALTIME TRACK CRACK DETECTION, FIRE SAFETY & BIO-ENTITY DETECTION USING AI & IOT

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Keywords:
Smart Railway Monitoring System, Real-Time Crack Detection, Fire Safety Monitoring, Bio-Entity Detection, Artificial Intelligence (AI), Internet of Things (IoT), Computer Vision Sensor Integration, Vibration Sensors, Smoke Detection, Real-Time Data Processing, Railway Safety Automation, Object Detection, Wireless Communication (Wi-Fi).

Introduction:

1. Railway transportation is a critical component of global infrastructure, providing a reliable and efficient means of moving people and goods over long distances.
2. This research presents a novel approach to railway track crack detection utilizing computer vision techniques implemented on a Raspberry Pi platform, integrated with IoT connectivity for real-time monitoring and alert generation.
3. Traditional railway track inspection methodologies predominantly rely on manual inspection or specialized track inspection vehicles that operate periodically.

Objectives:

Design and develop a cost-effective, autonomous railway track crack detection system using Raspberry Pi, webcam, and IoT technologies

1. Design and develop a cost-effective, autonomous railway track crack detection system using Raspberry Pi, webcam, and IoT technologies
2. Implement and optimize image processing yolo v8 algorithms capable of identifying various types of railway track cracks with at least 90% accuracy under diverse environmental conditions
3. Integrate precise location tracking to enable accurate defect localization within 2 meters of the actual position.

Methodology:

The proposed *Smart Railway Monitoring System* integrates Artificial Intelligence (AI) and Internet of Things (IoT) technologies to ensure real-time railway safety through continuous monitoring and automated alert mechanisms.

1. Data Acquisition:
   Sensors such as vibration sensors, thermal sensors, gas/smoke detectors, and cameras are deployed along railway tracks and compartments.
2. Real-Time Crack Detection:
   High-resolution cameras capture track images, which are processed using AI-based computer vision models to detect cracks and structural anomalies.
3. Fire Safety Monitoring:
   Temperature and smoke sensors continuously monitor environmental conditions. AI algorithms analyze abnormal patterns to detect potential fire hazards.
4. Bio-Entity Detection:
   AI-powered image recognition identifies human or animal presence on tracks to prevent accidents.
5. Data Processing & Communication:
   IoT modules (e.g., Node MCU/Raspberry Pi) transmit real-time data to a cloud server for analysis.
6. Alert System:
   Automated alerts are sent to railway authorities via mobile apps or dashboards for immediate action.

Result and Conclusion:

1. System will help to reduce accidents caused due to railway cracks, fire and also accidents happening at gate crossings.
2. An automatic method is used to inspect the railway track for crack detection which helps in maintenance and monitoring the condition of railway tracks without any errors.
3. Automatic opening and closing of gate will reduce the rate of accidents and also there is no need for a Manuel operator.
4. System uses a fire sensor to detect the fire. Quick actions are taken to avoid spreading of fire to other compartments and alert the passengers.
5. Developed system architecture integrating sensors, AI models, and cloud platform Created user interface/dashboard for monitoring alerts.
6. Conducted crack detection tests using sample railway track images. Simulated fire conditions to test sensor responsiveness. Tested bio-entity detection using trained AI models (humans/animals).
7. Achieved accurate crack detection with high precision. Real-time fire detection with minimal delay. System demonstrated reliable data transmission and alert generation
8. An automatic method is used to inspect the railway track for crack detection which helps in maintenance and monitoring the condition of railway tracks without any errors.

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Future Scope:

1. This project provides a strong foundation for smart railway monitoring and demonstrates the viability of automated track inspection using embedded systems.
2. The robotic inspection system could also be upgraded for full-scale deployment on real railway networks instead of model tracks
3. In future developments, the system can be integrated with advanced computing technologies such as machine learning and AI-based image analysis. Instead of depending solely on binary IR crack detection, camera images can be analyzed by neural networks to automatically classify crack size, severity, and predicted risk.
4. Additionally, GPS integration could allow real-time geolocation mapping of detected faults. When a crack or obstacle is detected, the system could store the exact coordinates of the fault, enabling maintenance crews to locate and address the issue without ambiguity.