TRACK WATCH: DRONE SURVEILLANCE FOR SAFER RAILWAYS

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Introduction:

Railway networks are vital for efficient passenger and freight transport, forming a backbone of economic growth worldwide. However, the safety and reliability of these systems depend heavily on the condition of railway tracks, which are susceptible to defects like cracks, welding issues, and obstructions. These anomalies pose significant risks, including derailments, service disruptions, and financial losses. Traditional manual inspection methods are time-intensive, prone to errors, and fail to provide real-time insights, especially in vast and remote railway networks. To address these challenges, advancements in autonomous systems like drones, coupled with AI-powered defect detection, offer a transformative solution for proactive track monitoring and maintenance.

The system leverages a deep learning model (YOLOv5) to identify and detect anomalies such as cracks, track misalignments, and obstructions from video footage. The objective is to reduce manual inspection effort, improve safety, and ensure early detection of potential railway hazards. A manually operated drone captures video, which is later processed frame-by-frame. The results are presented on a user-friendly web dashboard for review and download.

Objectives:

1. To design and implement a drone-based system for autonomous railway track monitoring.
2. To integrate advanced AI algorithms for real-time detection and classification of track anomalies.
3. To establish a robust communication system for seamless data transmission, even in low-network areas.
4. To provide actionable insights and real-time alerts to railway operators through a cloud-based dashboard for enhanced decision-making.

Methodology:

The railway track monitoring system is modeled as an autonomous anomaly detection framework, with the drone as the primary agent. The goal of the system is to identify and report defects like cracks, welding problems, slag inclusions, undercuts, and obstructions on railway tracks. Main assumptions: Drones have high-resolution cameras and sensors that capture actual data in real time. Tracks and their surroundings have different environmental conditions, such as lighting and weather. It depends on the hybrid model of 4G/5G and LoRa when cellular networks are unstable. The operational environment is designed to simulate real-world railway conditions, and it includes:

● Track geometry data (e.g., alignments, joints).
● Dynamic environmental changes (e.g., low-light intensities, covered by vegetation).
● Network Conditions for Testing Communication Resiliency.

Result and Conclusion:

The initial implementation of the Drone-Based Railway Track Monitoring and Anomaly Detection System has successfully demonstrated the integration of drone navigation, video/image capture, and real-time crack detection using a YOLOv5 model. The trained model accurately detected anomalies and track gaps in both uploaded images and video frames, highlighting them with bounding boxes for clear identification.

Testing was conducted on both static datasets and real-time drone footage in a controlled environment. The system consistently produced accurate and reliable

results, validating the effectiveness of the crack detection pipeline. The Streamlit-based user interface enabled smooth interaction, allowing users to upload media, visualize outputs, and analyze model performance metrics efficiently.

While autonomous drone functionality and full-scale outdoor deployment are reserved for future development, the current system confirms that deep learning-based visual inspection can enhance railway safety and reduce manual effort. The project lays the groundwork for future expansion into autonomous patrol, real-time alerting, and integration with railway maintenance systems. Continued improvements will focus on drone stabilization, expanding training datasets, and enabling outdoor testing under varying conditions for broader applicability.

Project Outcome & Industry Relevance:

This project presents a cost-effective and practical solution for automated railway track inspection using drone surveillance and deep learning. By integrating real-time video analysis with a YOLOv5-based anomaly detection system, it enhances railway safety through timely identification of cracks and track gaps.

The solution holds strong relevance for the transportation and infrastructure industry, where manual inspections are labor-intensive and time-consuming. Railway authorities and infrastructure maintenance companies can adopt this system for periodic inspections, reducing human effort, increasing precision, and minimizing accident risks. The project demonstrates how AI-powered drone monitoring can transform traditional inspection methods into smart, automated, and scalable solutions for safer rail networks.

Project Outcomes and Learnings:

The project successfully demonstrated real-time railway track crack detection using drone surveillance integrated with a YOLOv5-based anomaly detection model. We learned how to fine-tune deep learning models for object detection, process real-time video feeds, and build a responsive Streamlit-based web interface. The experience enhanced our skills in computer vision, drone-based monitoring, and system integration, while emphasizing the importance of testing, debugging, and teamwork in developing reliable, real-world AI applications.

Future Scope:

The future scope of this project includes:

1. Autonomous Drone Navigation**:** Enhancing the drone with GPS and path-planning algorithms for fully automated railway line inspection without manual control.
2. Extended Dataset Training**:** Expanding the dataset with varied track conditions, lighting scenarios, and crack types to improve model accuracy and robustness.
3. Real-Time Alerts**:** Integrating alert systems that notify authorities immediately upon crack detection for faster response and maintenance.
4. Energy Efficiency**:** Exploring lightweight solar charging solutions or swappable battery mechanisms for longer drone flight durations.
5. Integration with Railway Infrastructure**:** Collaborating with railway departments to deploy the system in real-world environments for preventive maintenance and safety.
6. Multi-Drone Coordination**:** Introducing multiple drones with coordinated scanning to cover longer distances and increase operational efficiency.