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Research Paper

# AI BASED PREDICTIVE MAINTENANCE SYSTEM FOR RAILWAY ASSET

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**ABSTARCT**- ***This project presents on AI based predictive maintenance framework for critical railway assets, specifically focusing on track geometry, switching points and rolling stock components. The proposed architecture utilizes a hybrid Deep Learning (DL) model combining Long Short-Term Memory (LSTM) networks and Convolutional Neural Networks (CNNs) to extract spatial-temporal features and forecast Asset Health Index (AHI) degradation curves. Validated on a real-world regional transit dataset, the AI framework demonstrated a 94.2% accuracy in Remaining Useful Life (RUL) estimation and successfully predicted critical track faults up to 14 days in advance. The implementation of this system yields a projected 22% reduction in unplanned downtime and a 15% decrease in overall maintenance expenditure, offering a scalable solution for cognitive asset management in next-generation rail infrastructure. The modern railway networks demand high operational availability, safety, and cost-efficiency, rendering tranditional reactive and time-based scheduled maintenance paradigms inadequate.***

***KEYWORDS: Artificial Intelligence(AI), Predictive Maintenance, Railway Assets, Machine Learning, Sensors, IOT Sensors, Aset Health Inex (AHI), Remaining Useful Life(RUL), Time-Series Telemetry.***

## INTRODUCTION

The operational reliability and structural integrity of railway infrastructure are critical prerequisities for socioeconomics stability and passenger safety.

It frequently results in the premature disposal of components that skill posses

substantial Remaining Useful Life(RUL). AI based predictive maintenance system for railway assets.

## LITERATURE SURVEY

AI-based predictive maintenance overcomes this limitation by analysing sensor data, maintenance records, and operational information to identity potential failures before they occur. Machine Learning algorithms recognize fault patterns, while IOT sensors provide real-time condition monitoring of tracks, wheels, bearings, and signalling equipment. This intelligent approach helps reduce maintenance costs, minimize service interruptions, improve asset life, and enhance passenger safety. Recent study materials also emphasize that integrating AI with Big Data analytics and cloud-based monitoring supports faster decision-making and more reliable railway maintenance. Railways depend in assets such as tracks.

## RELATED WORK

Railway Engineering and Maintenance Engineering textbooks explain that maintenance methods cannot always prevent unexpected failures. Recent research shows that AI and Machine Learning can accurately predict faults using historical maintenance data. IOT sensors enable continuous monitoring of railway assets such as tracks, Wheels and bearings. Big Data analytics improves fault detection and maintenance planning by analysing real-time operational data. Overall AI-based predictive maintenance enhances safety, reduces , maintenance costs, and increases the reliability of railway systems.

## EXISTING SYSTEM

The existing railway maintenance system mainly relies on corrective and preventive maintenance methods. Maintenance Is performed at fixed intervals or only after a fault occurs. These methods often lead to unexpected equipment failures, higher maintenance costs, and increased downtime. Fault detection is mostly based on manual inspections and periodic monitoring. As a result, maintenance planning is less efficient and may affect railway safety and reliability.

## PROPOSED SYSTEM

The proposed system uses Artificial Intelligence (AI) and Machine Learning(ML) to predict asset failures before they occur. IOT sensors continuously collect real-time data from tracks, wheels, bearings, and signalling systems. AI analyses this data to detect abnormal conditions and generate early maintenance alerts. This approach reduces unexpected failures, maintenance costs, and downtime. It also improves railway safety,

asset reliability, and overall operational efficiency.

## SYSTEM ARCHITECTURE

The system architecture consist of IOT sensors, a data collection module, on AI prediction engine, and a maintenance alert system. Sensors continuously collect real-time data from railway assets such as tracks, wheels, and bearings. The collected data is stored and pre-processed before being analysed by Machine Learning algorithms. The AI model predicts possible faults and estimates the health of railway assets. Finally, maintenance alerts are sent to railway engineers for timely inspection and repair.

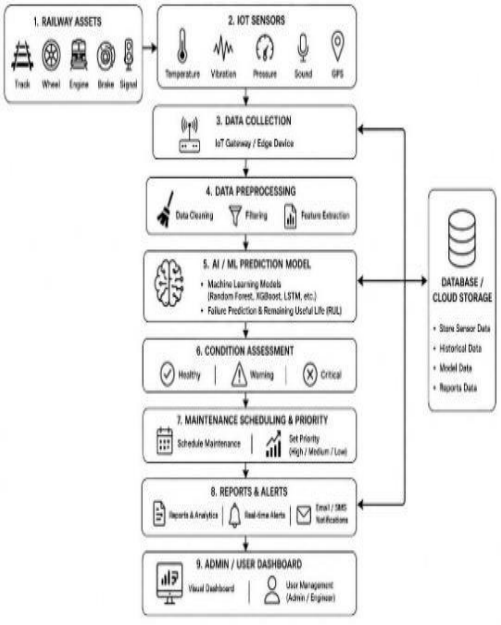


**Fig 1: System Architecture**

## METHODLOGY DESCRIPTION

The methodology of the AI based predictive maintenance system for railway assets. The proposed system collects real-time data from railway assets using sensors. The collected data is cleaned and processed before being analysed by on AI model. The AI compares the current data with previous maintenance records to identify unusual patterns. If a possible fault is detected the system predicts the failure in advance. Finally, an alert is sent to the maintenance team so that repairs can be carried out before a breakdown occurs, improving safety and reducing delays.

## RESULTS AND DISCUSSION

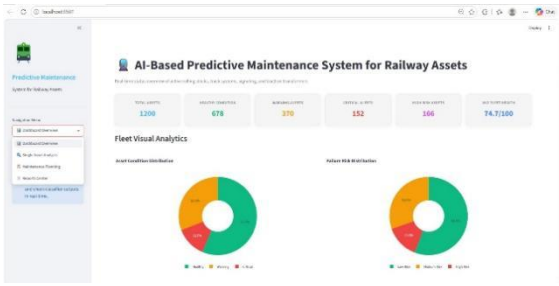


**Fig 2: Fleet Visual Analytics Dashboard**

This dashboard provide a real-time overview of railway assets. It displays the total assets, health assets, warning assets, critical assets, and average health score.

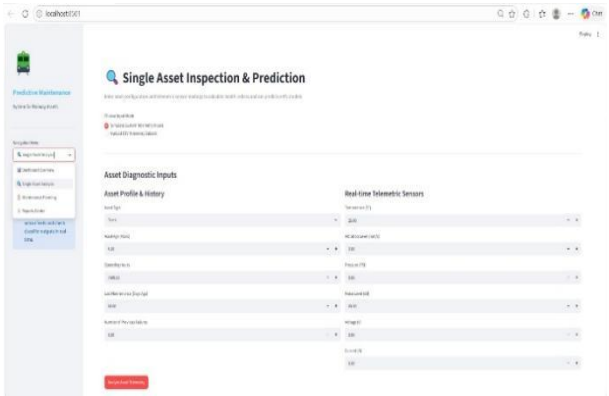

**Fig 3: Single Asset Inspection and Prediction**

This page displays the inspection of a single railway asset. It analyses sensor values, diagnostic signals, and asset profile information to predict the health condition.

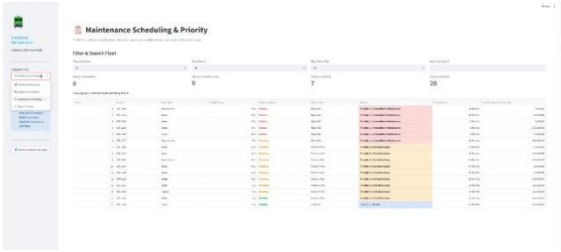


**Fig 4: Maintenance Scheduling and priority**

This page displays the maintenance schedule and priority railway assets based on AI prediction.

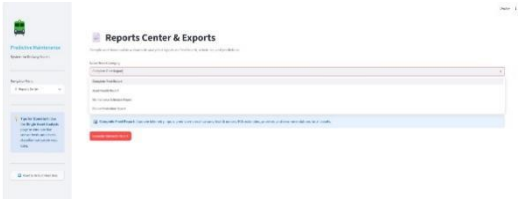


**Fig 5: Reports Center and Exports**

This page allows users to generate and export AI based predictive maintenance reports.

## CONCLUSION

The AI Based predictive maintenance system for railway assets. This project uses AI to identify railway equipment problems before they become serious. It helps maintenance teams take action at the right time instead of waiting for failures.

This improves passenger safety and reduces train delays. It also lowers maintenance costs and increases the life of railway assets. Overall, AI-based predictive maintenance makes railway operations smarter, safer, and more reliable.

## FUTURE SCOPE

The approach AI based maintenance system for railway asset Future studies will investigate the optimization of the deep learning pipeline via network pruning, quantization, and knowledge distillation to facilitate the development of models directly onto resource-constrained edge-computing devices situated trackside or onboard rolling stock. Research will explore advanced deep transfer learning techniques to generalize learned degradation representation across highly heterogeneous rail networks with varying track gauges, climatic conditions, and axle-load specifications without requiring extensive model retraining. Integrating explicit mechanical stress constraints and domain-specific material degradation physics.

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