# Automatic Fault Detection in Railway Tracks Using Deep Learning

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***Abstract*—Railway transport plays a crucial role in public transportation due to its affordability, speed, and frequency. However, the safety and reliability of railway systems are frequently compromised by undetected cracks and faults in tracks and fasteners, which are often missed due to the limitations of manual inspection methods. Existing automated systems, though promising, often fall short in real-world performance due to reliance on pre-trained models that lack domain-specific accuracy. This paper proposes an advanced deep learning-based fault detection system that combines the strengths of ResNet and EfficientNet architectures to enhance defect identification. ResNet's residual learning overcomes vanishing gradient issues, allowing the system to learn intricate fault patterns from deeper networks.**

***Index Terms*—Railway fault detection, Deep learning, Res-Net, Efficient Net, Track crack detection, Fastener defect identification, Image analysis, Automated inspection, public transport safety**

## I.INTRODUCTION

Railway transport remains one of the most vital and widely used modes of public transportation globally, owing to its affordability, speed, and high frequency of service. Millions of passengers and tons of cargo rely on railways daily, making their safety and reliability critical to public infrastructure. However, maintaining this safety presents a considerable challenge, as railway tracks and fasteners are exposed to continuous stress, environmental conditions, and wear and tear. Even minor cracks or faults, if left undetected, can lead to severe accidents, endangering lives and causing significant economic loss.

## II.LITERATURE SURVEY

[1] James *et al (2019). "*TrackNet - A Deep Learning Based Fault Detection for Railway Track Inspection"
The proposed system uses a multi-stage deep learning approach to automate railway track inspection. It begins with image segmentation to isolate the track, followed by cropping to focus on the area of interest.
[2] Welankiwar, S. Sherekar, A. P. Bhagat and P. A. Khodke (2018), "Fault Detection in Railway Tracks Using Artificial Neural Networks (2018)"
The system automates railway fault detection using an artificial neural network trained on a custom image dataset. A camera on the inspection vehicle captures track images, which the model analyzes in real time to detect defects.
[3] T. P. K. Nandan, T. Rahul, G. G. Bhavani and K.Narsimha(2023) "Railroad Track Defect Detection using Convolutional Neural Networks"
The proposed system leverages a Convolutional Neural Network (CNN) built with Python, TensorFlow, and Keras to automate railway track inspection. Images of the tracks are captured and preprocessed before being fed into the trained CNN model, which distinguishes between defective and non-defective sections.

## III. PROPOSED METHODOLOGY

Res-Net:
Res-Net, or Residual Network, is in very deep neural a deep 5 learning architecture designed to address the vanishing 26 networks. Its primary use case is image classification, but it has also object detection, segmentation, and medical imaging. Res-Net assumes that gradient problem been widely applied in deeper

networks can learn complex features, but training deep networks directly can result more in degraded performance due to vanishing gradients[3].

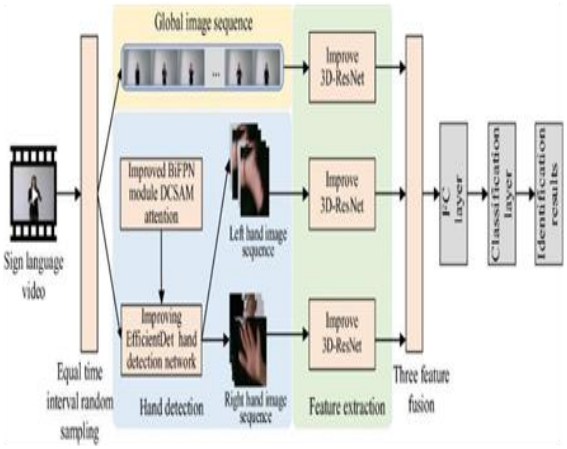



*Figure 1. ResNet*

EfficientNet :

EfficientNet is a deep learning architecture known for its optimized balance between model size, accuracy, and computational cost. It is primarily used in image classification, object detection, and transfer learning applications. EfficientNet operates on the principle that improving model performance is not solely about making the network deeper, but rather by scaling its depth, width, and resolution in a balanced way. This compound scaling approach allows EfficientNet to achieve high accuracy while maintaining computational efficiency and reducing memory requirements [1].

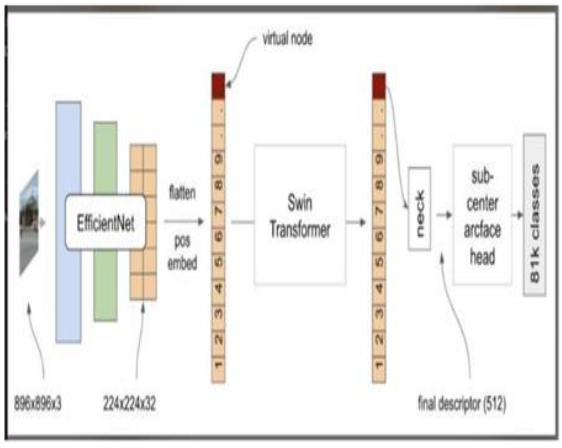



Figure 2. EfficientNet

IV. FLOWCHART

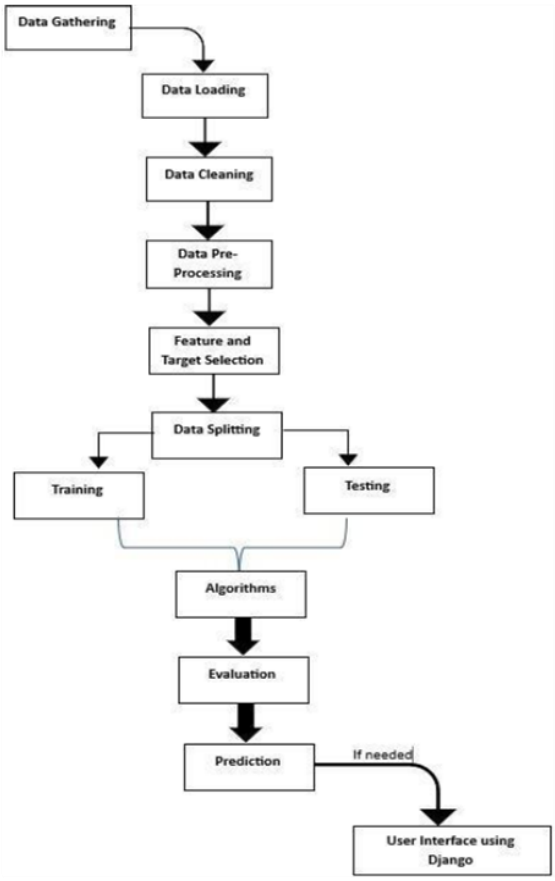



Figure 3. Flow Chart

- Image Capture and Upload

The system shall capture images of railway tracks and fasteners using high-resolution cameras, or it shall allow authorized users to upload track images directly into the system for analysis [8].

- Pre-processing of Images

The system shall preprocess the uploaded or of captured images, including resizing, normalization, and noise removal, to prepare them for analysis by deep learning models.

- Feature Extraction Using Res- Net and Efficient Net

The system shall extract visual features from the preprocessed images using both Res-Net and Efficient Net models to enhance defect detection [2]..

- Defect Classification

The system shall classify the detected defects into categories such as cracks in tracks and faults in

fasteners, providing specific label to identified defects.

- Automated Fault Detection Process

The system shall automatically scan the images and detect faults without requiring manual intervention during the detection phase [9].

- Detection Results Display

The system shall display the detection results to the user, including whether a defect is found, the type of defect, and its location if applicable.

- Accuracy Metrics Display

The system shall provide accuracy metrics for each prediction, showing how confident the system is about the defect classification.

## V. SCHEMATI EXPLANATION

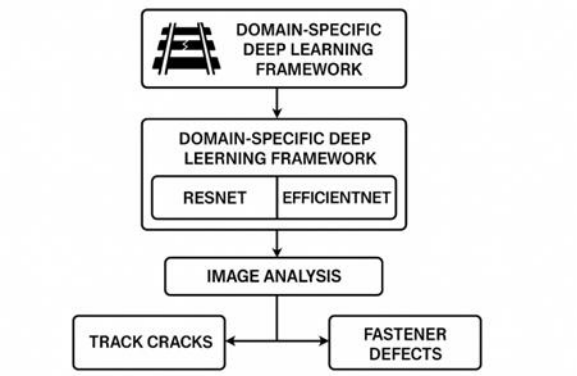
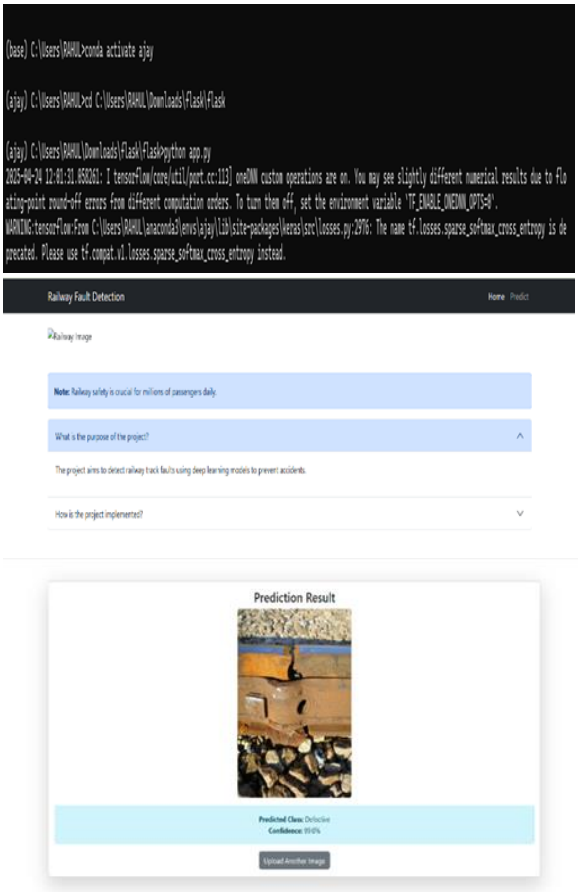



Figure 3. Schematic Diagram

- Requirement Gathering and analysis − All possible requirements of the system to be developed are captured in this phase and documented in a requirement specification document[5].
- System Design − the requirement specifications from first phase are studied in this phase and the system design is prepared. This system design helps in specifying hardware and system requirements and helps in defining the overall system architecture [7].
- Implementation − with inputs from the system design, the system is first developed in small programs called units, which are integrated in the next phase. Each unit is developed and tested for its functionality, which is referred to as Unit Testing [2].
- Integration and Testing − All the units developed in the implementation phase are integrated into a system after testing of each unit. Post integration the entire system is tested for any faults and failures [4].
- Deployment of system − Once the functional and non-functional testing is done; the product is deployed in the customer environment or released into the market.
- Maintenance − There are some issues which come up in the client environment. To fix those issues, patches are released. Also, to enhance the product some better versions are released. Maintenance is done to deliver these changes in the customer environment [1].

## VI. RESULT




## VII. APPLICATIONS

- Railway Track Fault Detection and Monitoring
- Predictive Maintenance

- Automated Inspection Systems
- Railway Safety Enhancement
- Railway Asset Management
- Cost Reduction and Resource Optimization
- AI-Driven Railway System Upgrades

## VIII. ADVANTAGES

- Enhanced accuracy in detecting railway track faults.
- Reduced computational costs through optimized feature utilization.
- Faster identification of potential hazards, improving safety.
- Deeper learning capabilities addressing complex datasets.
- Increased reliability in fault detection, minimizing accident risks.

## IX. CONCLUSION

This study presents an advanced deep learning-based system for railway track fault detection, addressing the limitations of manual inspections and existing automated systems. By combining ResNet's powerful residual learning capabilities with EfficientNet's optimized feature extraction, the proposed system ensures more reliable identification of cracks and fastener defects. The hybrid approach achieves an accuracy of 89%, effectively balancing detection performance and computational efficiency, making it suitable for real-time monitoring. The system's ability to quickly detect and classify faults helps prevent accidents, reduces downtime, and ensures smoother railway operations. By improving the reliability of railway infrastructure, the proposed solution contributes to enhanced passenger safety and cost-effective maintenance practices, ultimately supporting the modernization of railway systems.

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