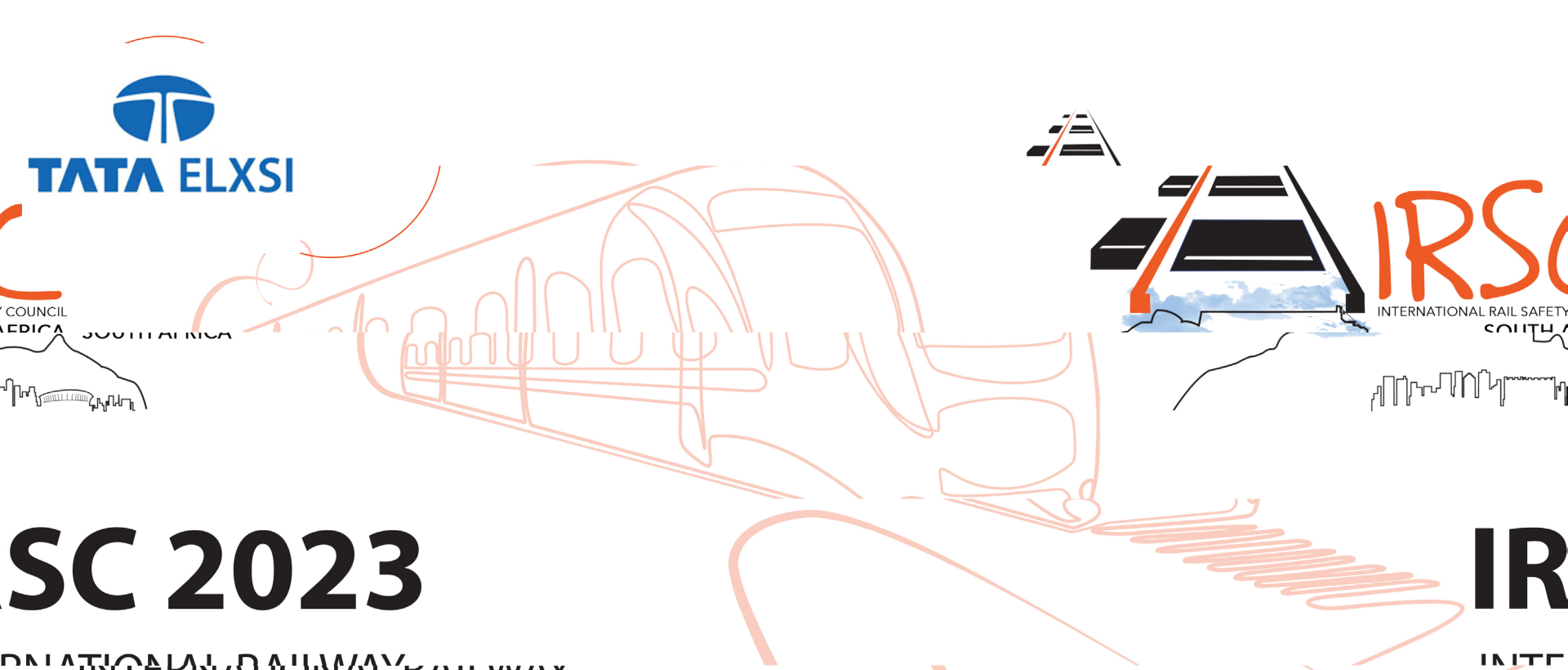


TATA ELXSI

INTERNATIONAL RAIL SAFETY

SC 2023

IR

INTERNATIONAL RAILWAY
SAFETY COUNCIL

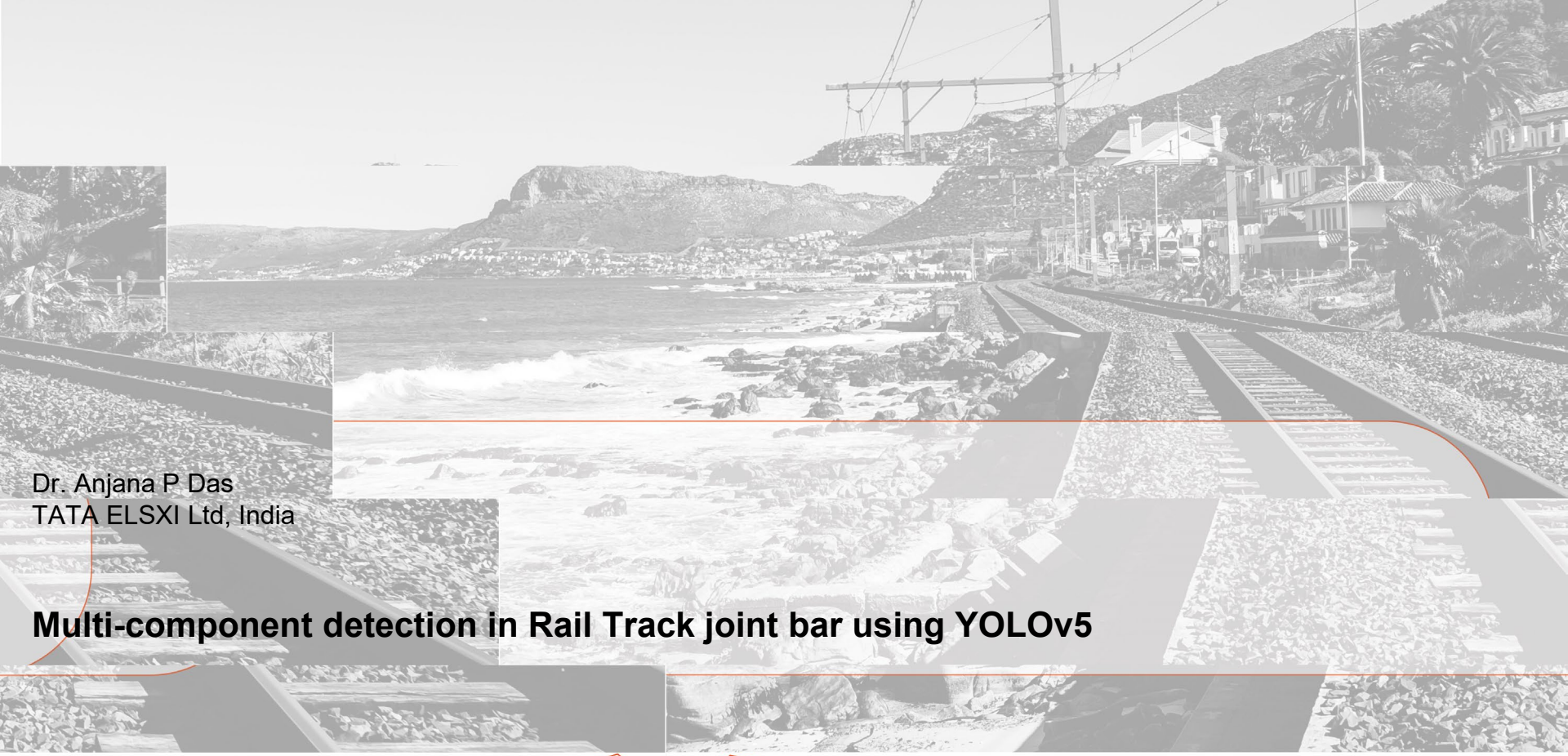
"Reshaping Railways in an Uncertain World"

CAPE TOWN, OCTOBER 1 - 6, 2023

HOSTED BY

RAILWAY SAFETY REGULATOR

RAIL SAFETY ON THE RIGHT TRACK



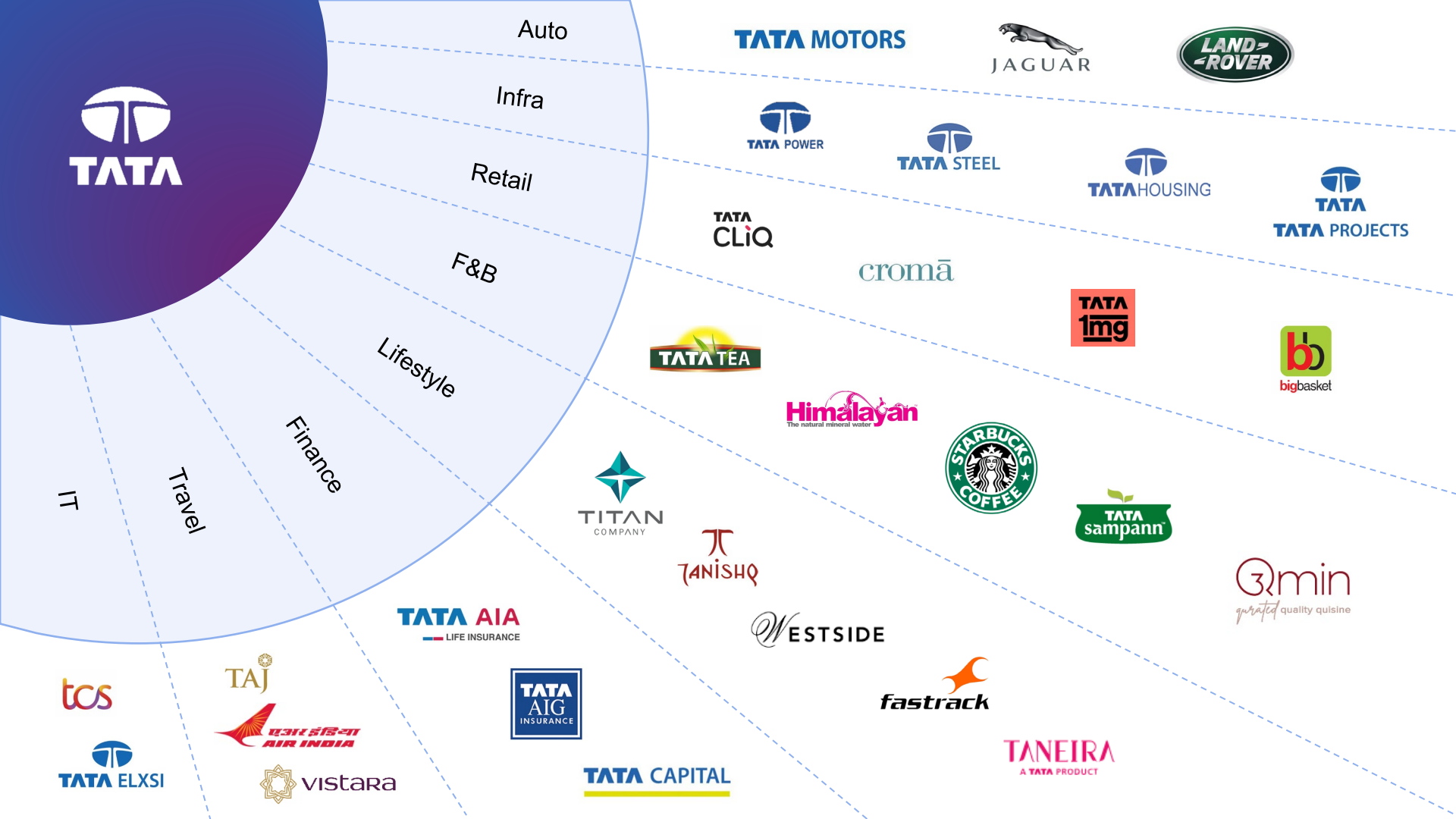
Dr. Anjana P Das
TATA ELSXI Ltd, India

Multi-component detection in Rail Track joint bar using YOLOv5

India's Most Valuable Brand

India's Only Value-based Corporation – a Visionary, a Pioneer, a Leader, since 1868

9,35,000+	$ 128 B+	150+	150+
Employees	Revenue	Countries	Years of Legacy


TATA
Auto
Infra
Retail
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Lifestyle
Finance
Travel
IT
TATA MOTORS
JAGUAR
LAND ROVER
TATA POWER
TATA STEEL
TATA HOUSING
TATA PROJECTS
TATA CLiQ
croma
TATA 1mg
TATA TEA
bigbasket
Himalayan
The natural mineral water
STARBUCKS COFFEE
TATA sampann
TITAN COMPANY
TANISHQ
Qmin
curated quality cuisine
TATA AIA LIFE INSURANCE
WESTSIDE
tcs
TAJ
TATA AIG INSURANCE
fastrack
AIR INDIA
TANEIRA
A TATA PRODUCT
TATA ELXSI
vistara
TATA CAPITAL

TATA ELXSI BUSINESS OVERVIEW

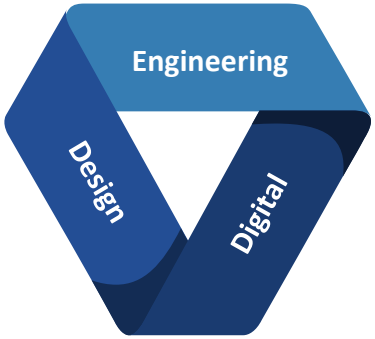
12000+ Engineers

13.4% YoY Growth

32+ Years in Business

33 Cities Worldwide

CORE SERVICES



Transportation

RAIL

- Smart Mobility
- Rolling Stock and Systems
- Wayside & Signalling

AUTOMOTIVE | OFF HIGHWAY

- Passenger Experience
- Connected & Autonomous
- Shared & Electric

Media & Communication

BROADCAST & MEDIA

- OTT Streaming
- RDK, Android TV, CPE
- QoE, QoS, Customer Experience

COMMUNICATIONS

- 5G, SDWAN
- Network Transformation
- Digital Transformation

Healthcare

MEDICAL DEVICES

- Product Design
- Systems Engineering
- Regulatory Compliance

PHARMACEUTICALS

- Safety
- Packaging & Labelling
- Pharmacovigilance

TATA

Established 1989

Global HQ Bangalore

Global Presence

Headquartered in **Bengaluru** with offices around the globe including NA, EUROPE & APAC

NORTH AMERICA

Atlanta, Canada, Irvine, Naperville, Philadelphia, Santa Clara, Troy, Toronto

EMEA

Dubai, France, Germany, Ireland, London Digital Studio, Netherlands, Poland, Portugal, South Africa, Spain, UK

APAC

Japan, Malaysia

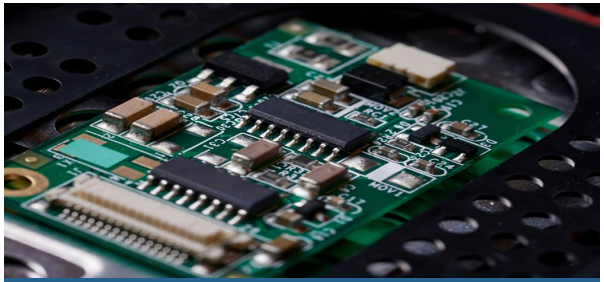
INDIA

Bengaluru (HQ), Chennai, Hyderabad, Mumbai, Pune, Trivandrum

Our Focus In Rail industry

Asset inspection and operations – **Safe** and **Efficient Operations**

Object detection, Perception systems **(Autonomous Systems)**



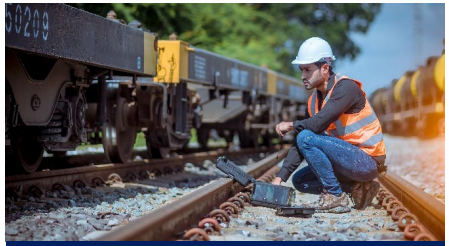
Safety Systems Development **(Full Ownership)**

Crunching the Vehicle product development cycle – Quick time to market **(Competitive Advantage)**

Seamless passenger experience, Passenger security & Surveillance **(Smart Mobility)**

IoT/Cloud for asset management and preventive maintenance **(Rolling stock & wayside)**

Inspection scope areas in Railroad operations



Track Inspection

Geometrical
- Curvature
- Gaps in assemblies
- Measurements

Structural
- Missing, loose parts

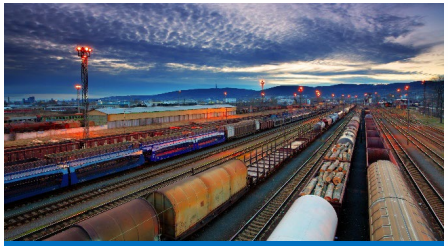
Damages
- Rail end batter
- Cracks on rail
- Broken, damaged crosstie

Rolling stock

Geometrical
- Couplers
- Structural deformation

Structural
- Door/ lid status
- Container contents

Identification
- Engine/ wagon ID



Yard

Structural
- Signage Health

Surveillance
- Theft
- Cleanliness, spillage

Way-side

Structural
- Signage Health
- Overhead Vegetation

Civil Structures
- Bridges
- Tunnel

Environment
- Landslide
- Object on track

Significance of Track Inspection

- Safety
- Maintenance Planning
- Legal and Regulatory Compliance

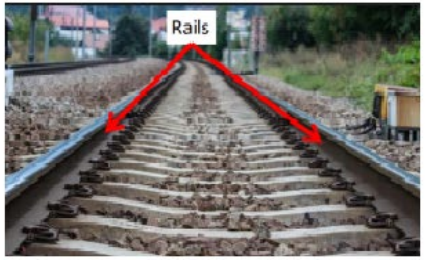
- Asset management
- Performance monitoring
- Continuous Improvement

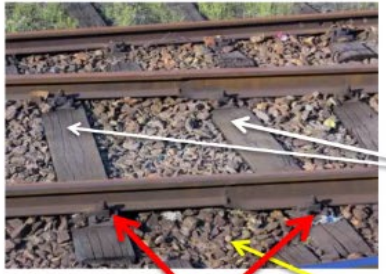
- Early Detection of Issues
- Operational efficiency
- Risk mitigation

- Customer satisfaction
- Enhanced Reliability
- Financial impact
- Reputation and Public Perception

Rail Track Elements

Fish plates / Joint bar





Sleepers

Fastenings

Ballast

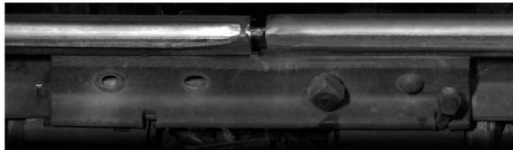
Rail Joint Bar

Joint bars are an essential component of rail infrastructure used to connect two distinct rail tracks without the need for welding.

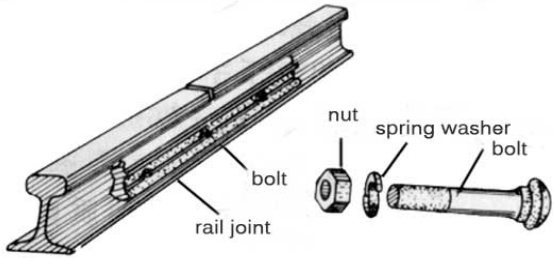
Bolt head

Nut

Holes

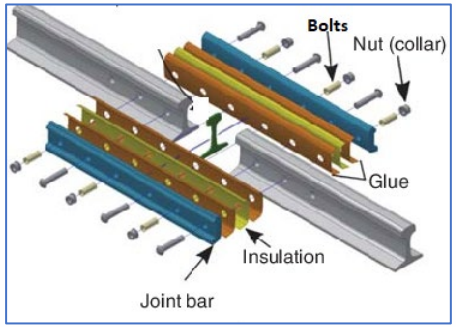


Joint Bar with two Missing Bolts Captured by the System

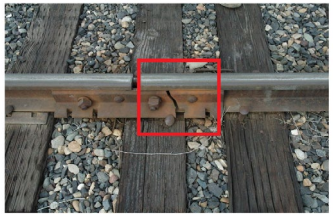


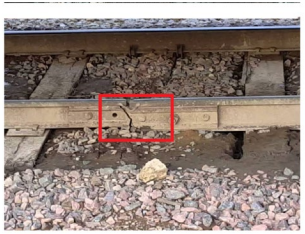
Defects in joint Bars

Joint Bar Integrity



Few versions of missing bolt





Few versions of crack

Rail Breakage

Missing bar

Rail fastener Defects

Conventional Approaches

Manual Inspection

Shortcomings of Manual Inspection

- Human Error
- Disruptions to the smooth functioning of railways.
- Time-consuming and Labor-intensive
- Limited geographic coverage

Shortcomings of Inspection Vehicles

- High Capital Cost
- Limited Accessibility
- Operator Dependency

Significance of Image-Based Solutions

- Research gap in image-based solutions
- Lack of literature work on defect detection , gap measurement from camera images

Inspection Vehicles

Joint Bar inspection

Track gage Inspection

Inspection with Drone Technology

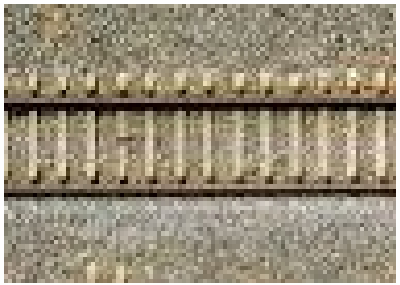
- Reliability in processing the experimental field data and defects
- Localization of defect in a particular area using latitude and longitude
- GUI based approach for method and results
- High-quality images that contain large information for monitoring and analysis

Solution Flow

Inspection Solution is Executed in Edge Computer

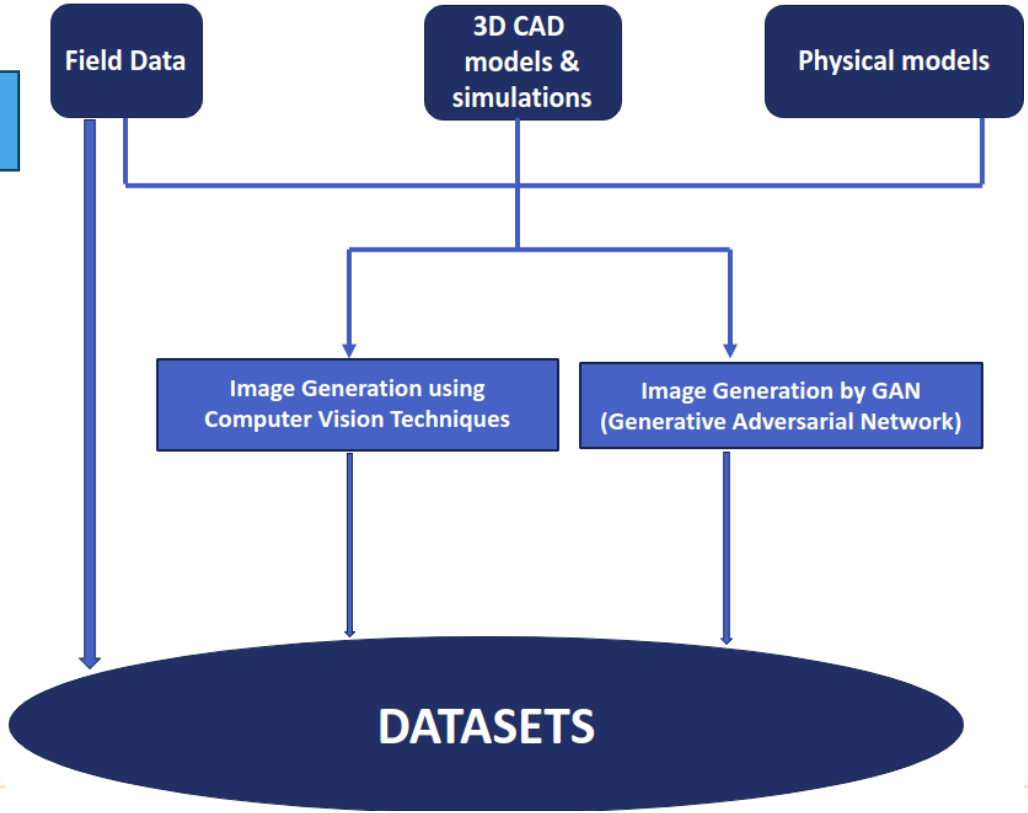
Cascaded Approach: Step-by-step detection of target component to eliminate errors

Hybrid of Computer Vision & AI/ML algorithms to achieve high accuracies



Data Set Creation

Synthetic Data Generation

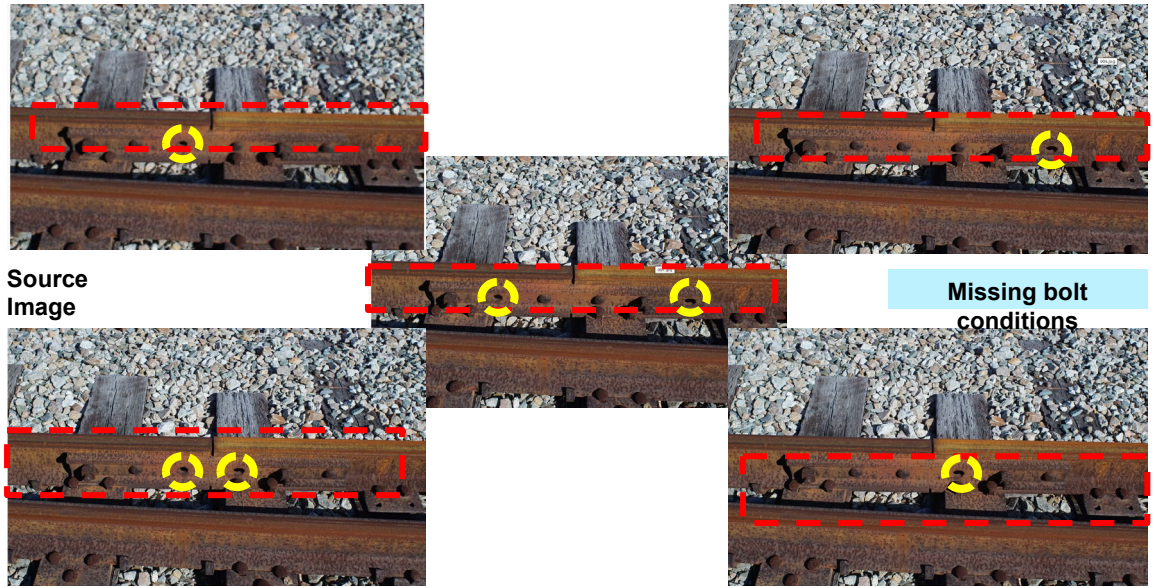


Development Approach – Synthetic Data Generation

Best Practices/ Innovations

Synthetic Data Generation tool – **Able to generate millions of training data from limited parent set**

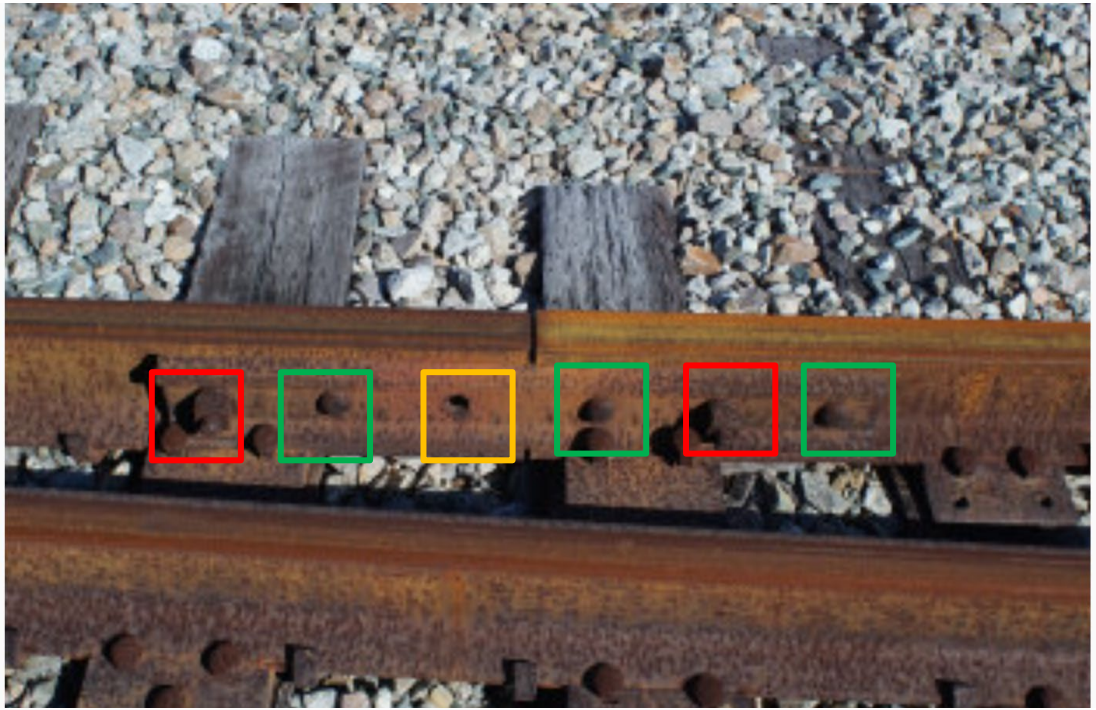
Customized Generative AI models



Automated 3D Model Generation

Loose bolt conditions

Multi-Component Detection



Nut_and _Bolt

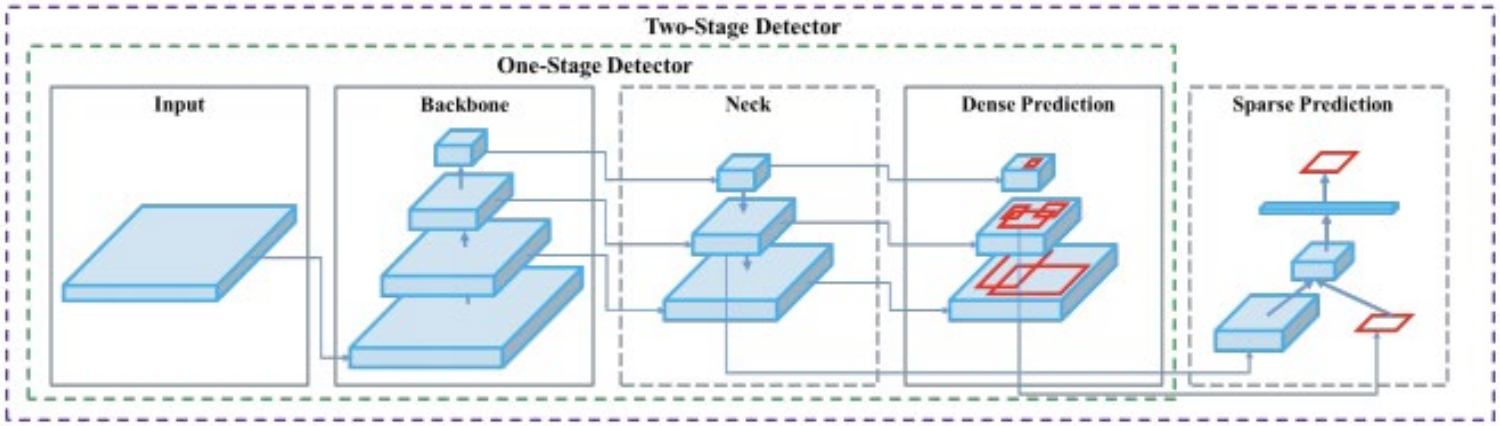
Bolt _head

Missing _nut _and_bolt

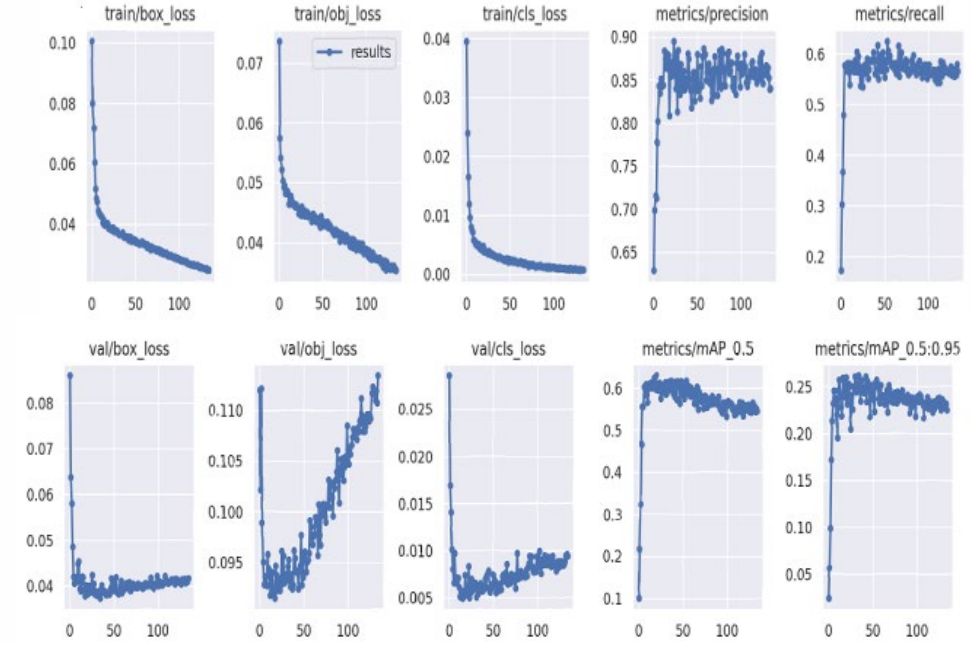
Multi-Component Detection-YOLO V5

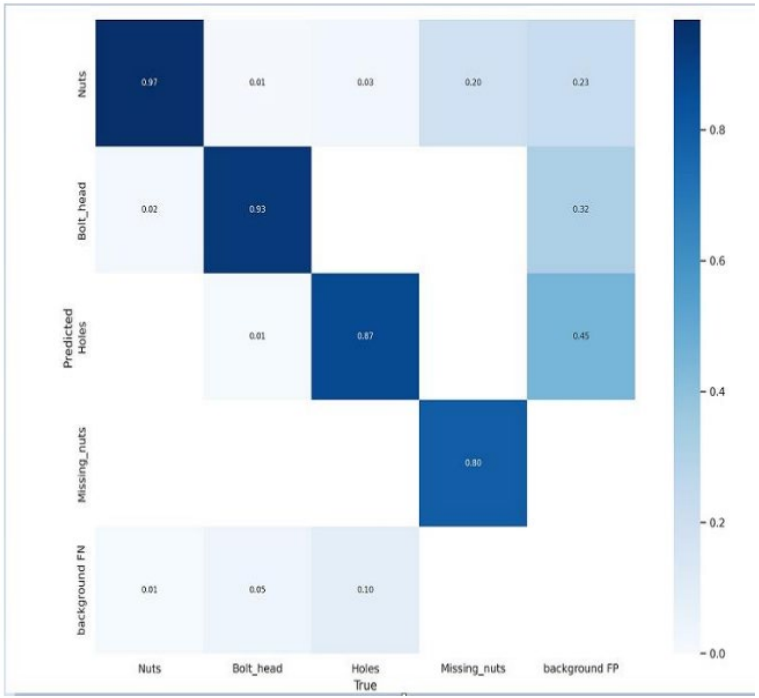
The YOLO network consists of three main pieces.

1. **Backbone**: A convolutional neural network that aggregates and forms image features at different granularities.
2. **Neck**: A series of layers to mix and combine image features to pass them forward to prediction.
3. **Head**: Consumes features from the neck and takes box and class prediction steps.



Experimental Results and Inferences





The training procedure took an average of 10 seconds for 86 batches during one epoch, and the evaluation process took an average of 9 seconds for 22 batches. Total execution time was 0.435 hours i.e. 26.1 minute for 100 epochs.

Experimental Results and Inferences

Hyper parameters	Values used for training	Model	Training Results -Prediction (%)
Learning Rate [lr-Final one cycle LR] Momentum Classification Loss gain Object loss gain	0.0001 0.984 0.5 1.0	Yolo5s.pt	Nut - 97 Bolt head - 93 Holes - 87 Missing Nut - 80
Learning Rate [lrf -Final one cycle LR] Momentum	0.001 0.937	Yolo5s.pt	Nut - 96 Bolt head - 89 Holes - 82 Missing Nut - 80
Learning Rate [lr] Learning Rate [lrf -Final one cycle LR] Classification Loss gain Object loss gain	0.01 0.01 0.3 0.7	Yolo5s.pt	Nut - 98 Bolt head - 83 Holes - 89 Missing Nut - null

Class name	Precision value	Recall value	Accuracy (%)
Nut	82.9	98.9	97.0
Bolt_head	80.1	94..8	94.6
Holes	73.1	89.6	87.6
Missing nut	0.64	98.7	80.0

Hyper parameter tuning constructed based on the learning rate and momentum and further optimized using the Adaptive Moment Estimation (ADAM) optimizer

Conclusion

IMPACT:

50x times savings in time for inspecting the same length of track compared to manual method.

KEY DIFFERENTIATORS

AUTONOMOUS

NON-INVASIVE

HIGH FIDELITY

NEXT GEN RAIL ASSET INSPECTION SOLUTION OPENS UP NEW BUSINESS MODELS

Thank You

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