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EMSD

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FETY COUNCIL

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IRSC 20

INTERNATIONAL RAILWAY SAF

"Reshaping Reimagining railway

CAPE TOWN, O

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RAILWAY SAFETY REGULATOR

RAIL SAFETY ON THE RIGHT TRACK

Mr. David YAM
Electrical and Mechanical Services Department

Train-borne Railway Infrastructure Inspection System

Electrical and Mechanical Services Department (EMSD)

- The **Railway Safety Regulator** which regulates safety of mass transit railways, tramways, and peak trams in Hong Kong
- The "**Innovation Facilitator**" of the Government to support and facilitate I&T application by government departments for service improvement and smart city development

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Railway Safety Regulator

MTR

香港電車
HK TRAMWAYS

"Innovation Facilitator"

E&M Inno-Portal

E&M InnoPortal®

EMSD launched an online technological demand matching platform in March 2018 to facilitate wider adoption of I&T.

"I&T Wishes" for resolving specific railway safety problems by I&T application

Railway Safety Regulator and railway operator

Pilot I&T Projects in Railway Environment

I&T Knowledge and Innovative Ideas

I&T Solution Provider (e.g. Universities and Research Institutes)

Background

Railway Network in Hong Kong

- 10 Heavy Rails
- 1 Light Rail & 1 High Speed Rail
- Long Track length
- Long Service Hours

Infrastructure Conditions Inspection

- Manual Visual Inspection
- Non-Traffic Hour (2-3 hours)
- Labour-intensive & Time-consuming

Matching of "I&T Wishes" and "I&T Solution" in E&M Inno-Portal

"I&T Wishes" for **enhancing efficiency of Infrastructure Conditions Inspection** by I&T application

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Railway Safety Regulator

MTR

Railway Operator

E&M InnoPortal®

EMSD launched an online technological demand matching platform in March 2018 to facilitate wider adoption of I&T.

Pilot I&T Projects in Train-borne Railway Infrastructure Inspection System

I&T Knowledge and Innovative Ideas

香港城市大學 City University of Hong Kong

I&T Solution Provider

IRSE

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Invention

The World's 1st Train-borne High Speed Scanning System

https://youtu.be/dwkecDy72L4

Silver Medal Award
International Exhibition of Inventions of Geneva in 2023

Detect & Predict the railway infrastructure defects

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System Design

Technology Adopted

1. 4th Generation LiDAR

- Enabling SLAM
- 10 Rotations (2.6 million points) per sec
- Global Shutter
- Rebuilt 3D BIM model
- Max Range: 50 Meter
- Vertical / Horizontal Field of View: 90˚ and 360 ˚

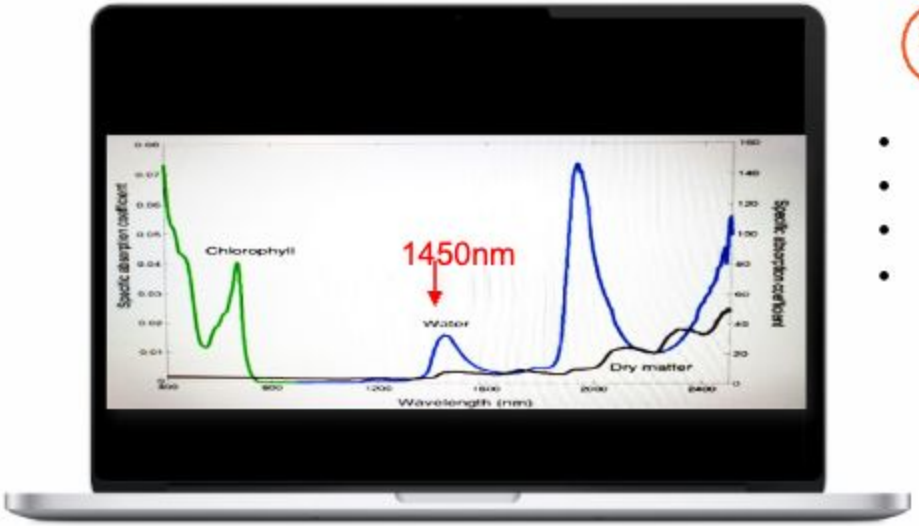
Technology Adopted

2. Stereo Computer Vision and Advanced AI Algorithms

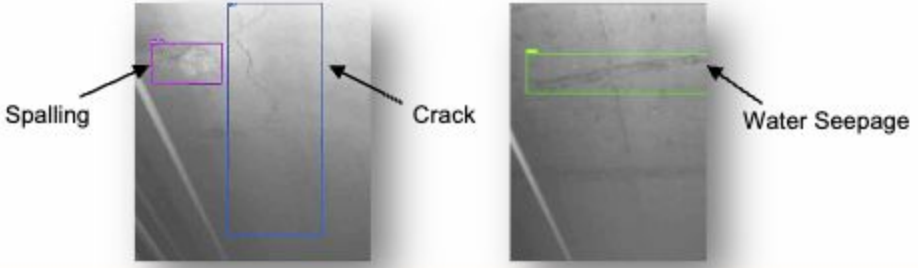
- Like a pair of human eyes
- Widen the view of scene and depth of view
- YOLOV4 and DINO-IR AI Models
- Enhanced detection accuracy
- Trend Prediction

Technology Adopted

3. Dual-band Infrared Imaging



- Non-Visible Light
- Near-infrared (850nm) & Short-wave infrared (1450nm)
- Expand the dynamic range of IR detection
- Distinguish the concrete crack and water seepage



Technology Adopted

4. 5G Edge Computing

- Real-time Detection at 80 km/h train speed
- Fully Automated
- Inspection during Service Hours

AI and Analytics Engine

Stage 1

YOLO V4 AI
On Train

- ✓ Light Weight AI
- ✓ Preliminary screening

Stage 2

DINO-IR AI
On Cloud Server

- ✓ Powerful AI
- ✓ Detailed Identification
- ✓ Positioning

Stage 3

Report Generation
On Cloud Server

- ✓ Reporting and trending
- ✓ Date, Time, Location, Types of defect, and snapshot photo

CLEANSING	EMBEDDING	SIMILARITY	HYBRID DECISION TREE	CONVOLUTION NEUTRAL NETWORK	FINAL DECISION MAKING
Data Cleansing & Transformation	N-Dimensional Tensor Matrix	Learning the Similarity	Data Compensation	Feature Extraction	Identify the types of defect

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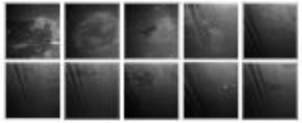
Target Result

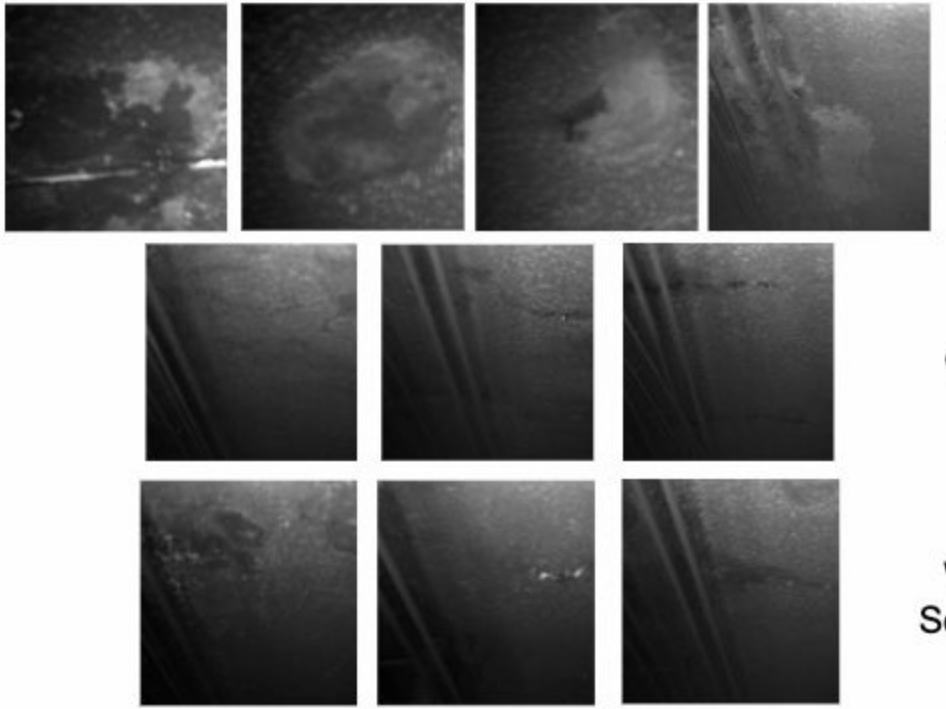
- **Concrete Spalling: 150mm(W) x 150mm (H) (±5%)**
- **Concrete Crack: 10mm (W) and 150mm (H) (±5%)**
- **Water Seepage: 150mm (W) x 150mm (H) (±5%)**
- **Trackside Equipment Displacement: 50mm (±5%)**
- **Overall Defect Detection Accuracy: 80%**

Tests and Results

Concrete Spalling, Concrete Crack and Water Seepage



Stage 1: Results from Preliminary Screening by YOLO V4 AI Model on Passenger Train



Spalling

Crack

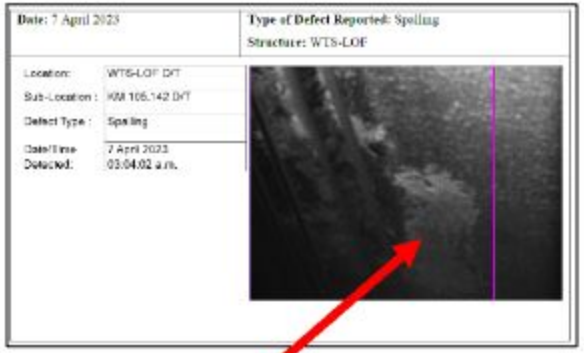
Water Seepage

Stage 2: Results from Detailed Identification by DINO AI Model on Cloud Server

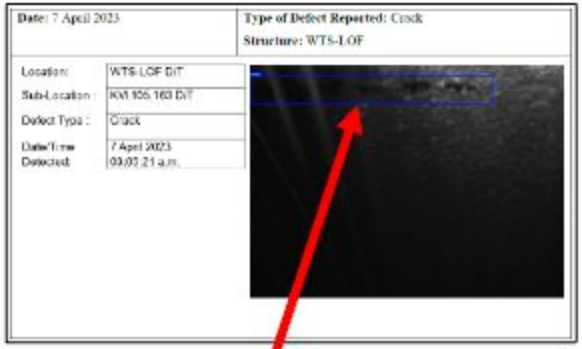
Tests and Results

Concrete Spalling, Concrete Crack and Water Seepage

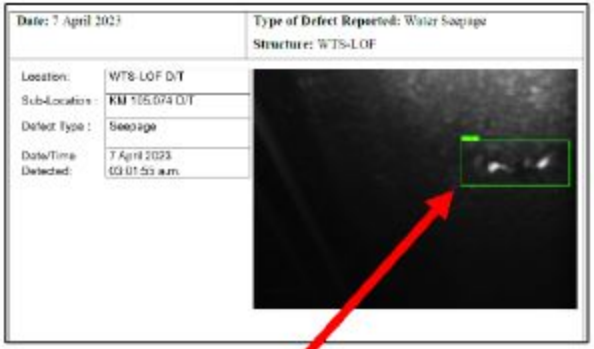
Stage 3: Report Generation on Cloud Server



Concrete Spalling



Concrete Crack



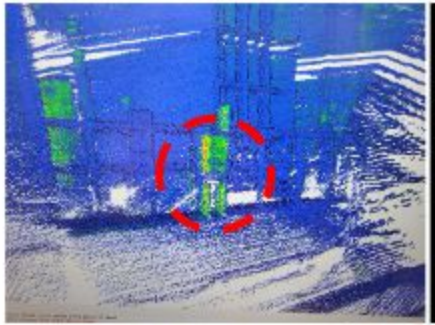
Water Seepage

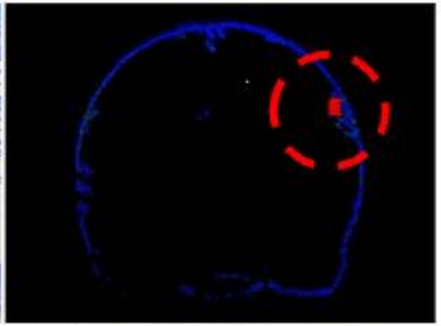
Tests and Results

Trackside Equipment Displacement

- Protection Barrier
- Tunnel Radio Amplifier
- Test Objects at High Speed Section (up to 80km/hr)

Loosen Cable Hanger





Protection Barrier Relocated

Door Opened

Tests and Results

Result of Defect Detection

- The system installation and testing was completed with trial run since March 2023

- Concrete Spalling: 81.7%
- Concrete Crack: 84.3%
- Water Seepage: 84.4%
- Trackside Equipment Displacement: All simulated scenarios detected in the testing

- Positioning of Defect Location: Accuracy range within 7m after using fixed point marker to specified position (i.e. platform head wall) along with point cloud

Further Enhancement

1. Enhancement of Detection Accuracy
- Getting more data for machine learning of AI Model

2. Positioning of Defect Locations
- Using more fixed point markers to specified positions with unique features along with point cloud

Conclusion

Train-borne Railway Infrastructure Inspection System

- Enhance efficiency of infrastructure conditions inspection by using artificial intelligence
- Facilitate trend analysis on detection and prediction of the railway infrastructure defects
- Better to utilize the maintenance window for other works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