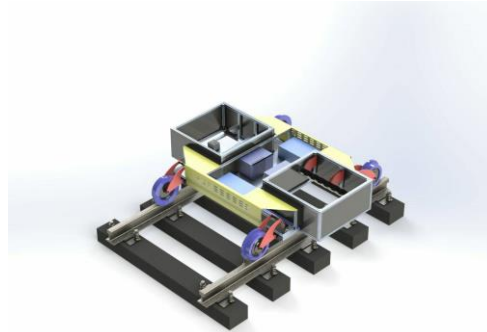


# Rail and Fastener Inspection by Machine Vision

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Rail and Modern Transport Research Center, NSTDA



# Motivation

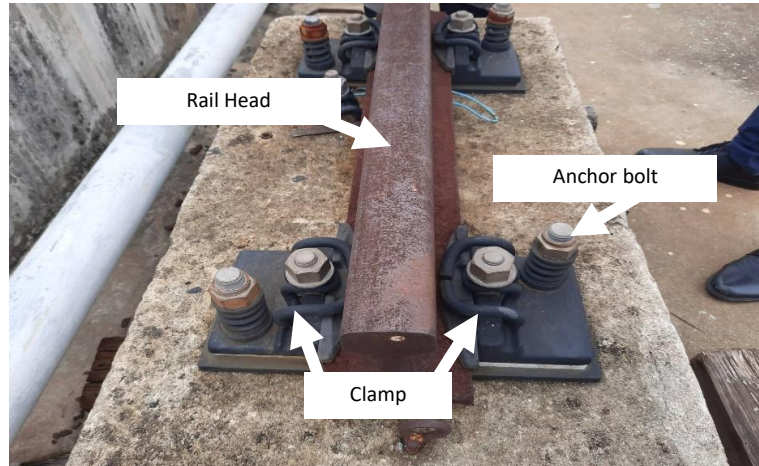
- การตรวจสอบรางและหมุดยึดรางรถไฟ เป็นสิ่งที่จำเป็น และต้องทำเป็นประจำสม่ำเสมอ เพราะเป็น อุปกรณ์ที่เกี่ยวข้องกับความปลอดภัยโดยตรง
- การกัดกร่อนทำให้ชิ้นส่วนบางชิ้นของหมุดยึดรางหักและไม่สามารถรับแรงได้
- ปัจจุบันมีวิธีตรวจสอบหมุดยึดรางวิธีเดียวคือ *การใช้บุคลากรเดินตรวจ* ซึ่งใช้เวลานานและเปลืองทรัพยากร



# Objectives

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- To help human in rail and fastener inspection
- Reduce human error in rail and fasteners inspection due to fatigue
- Reduce time in maintenance and inspection



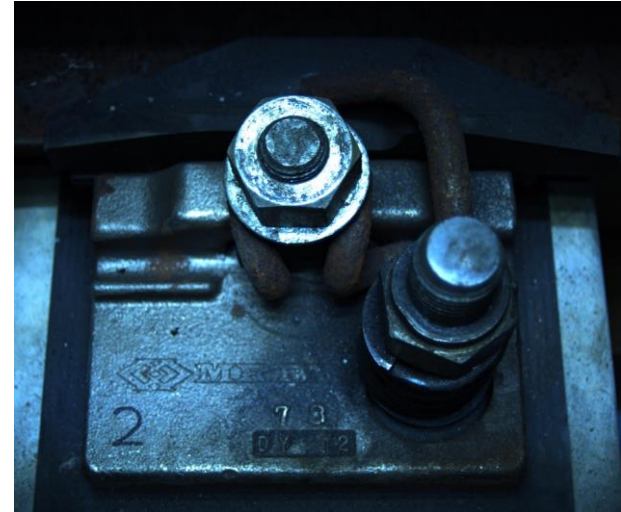
# Platform





# Sample images from area scan camera

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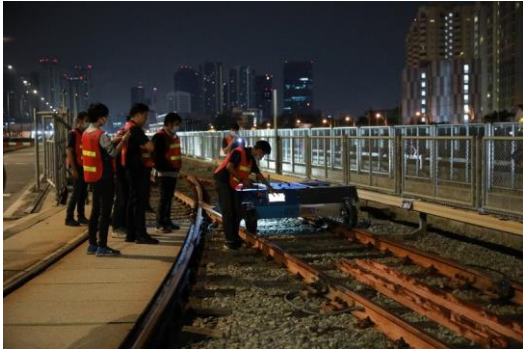
# Line scan images

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# Test track run on 30<sup>th</sup> March 2021

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# Test track run on 30<sup>th</sup> March 2021

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# Test track run

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Line scan camera



Area scan camera



# Field testing at MRT Depot (30 June 2021)

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Huay Kwang – Sirikitt Convention Center  
1 station

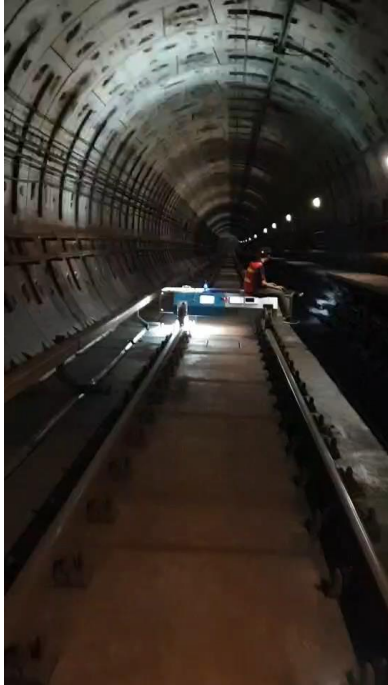
# Field testing at MRT Depot (30 June 2021)

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# Data Collections 2<sup>nd</sup> time (1 Sep 2021)

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Bangsue- Chatujak  
3 stations



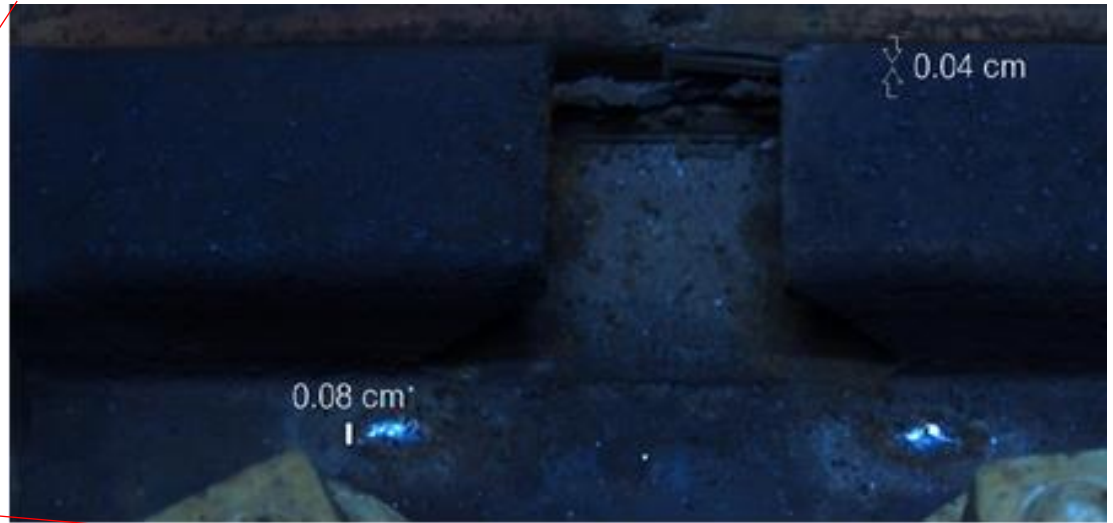
# Result from data collection#2

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# Resolution

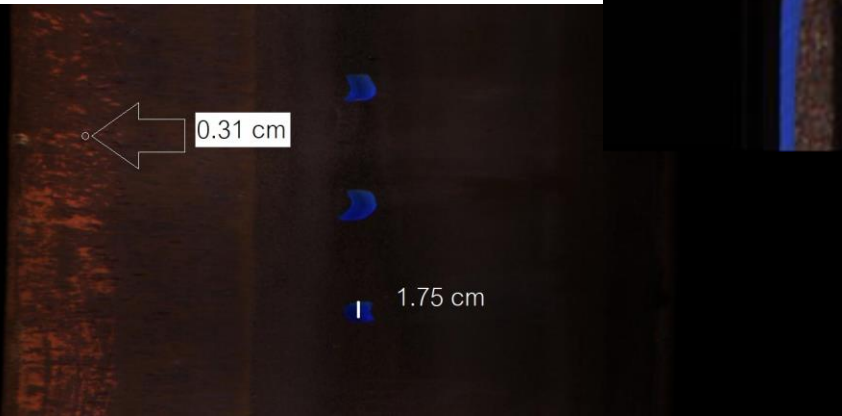
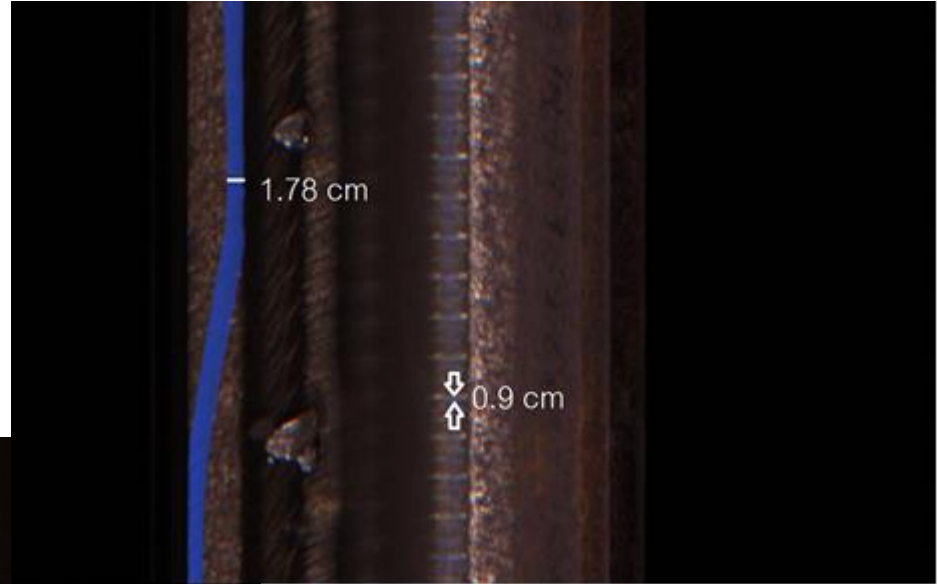
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For area scan camera, we are able to detect defects  $>1$  mm

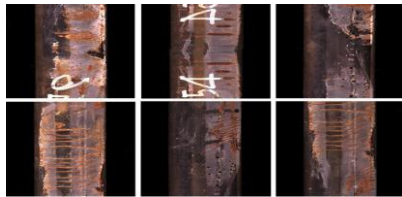
# Resolution

For line scan, we are able to detect defects  $> 1$  cm.



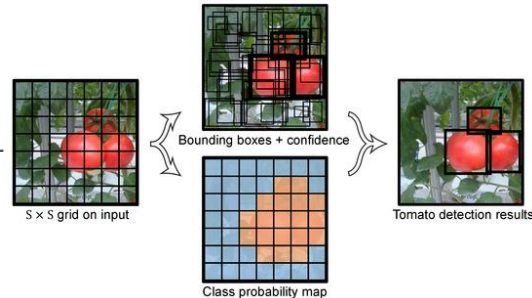
# Machine learning model

## Real inspection images



Lab produced positive samples

## YOU ONLY LOOK ONCE VERSION 5 (YOLOv5)

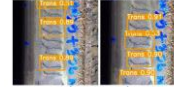


YOLOv5 (Real-time object detection system) classifier

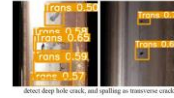
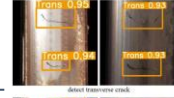
1st generated dataset model test with 1st generated dataset



1st generated dataset model test with 3rd MTEC's dataset



2nd generated dataset model test with 2nd generated dataset



Currently the model is being trained under on YOLOv5 Classifier and produced mark-up result for identifiable classes such as defect clamp, defect bolt, and their own normal variations

The preprocessing on image might be an option to increase the feature extraction accuracy

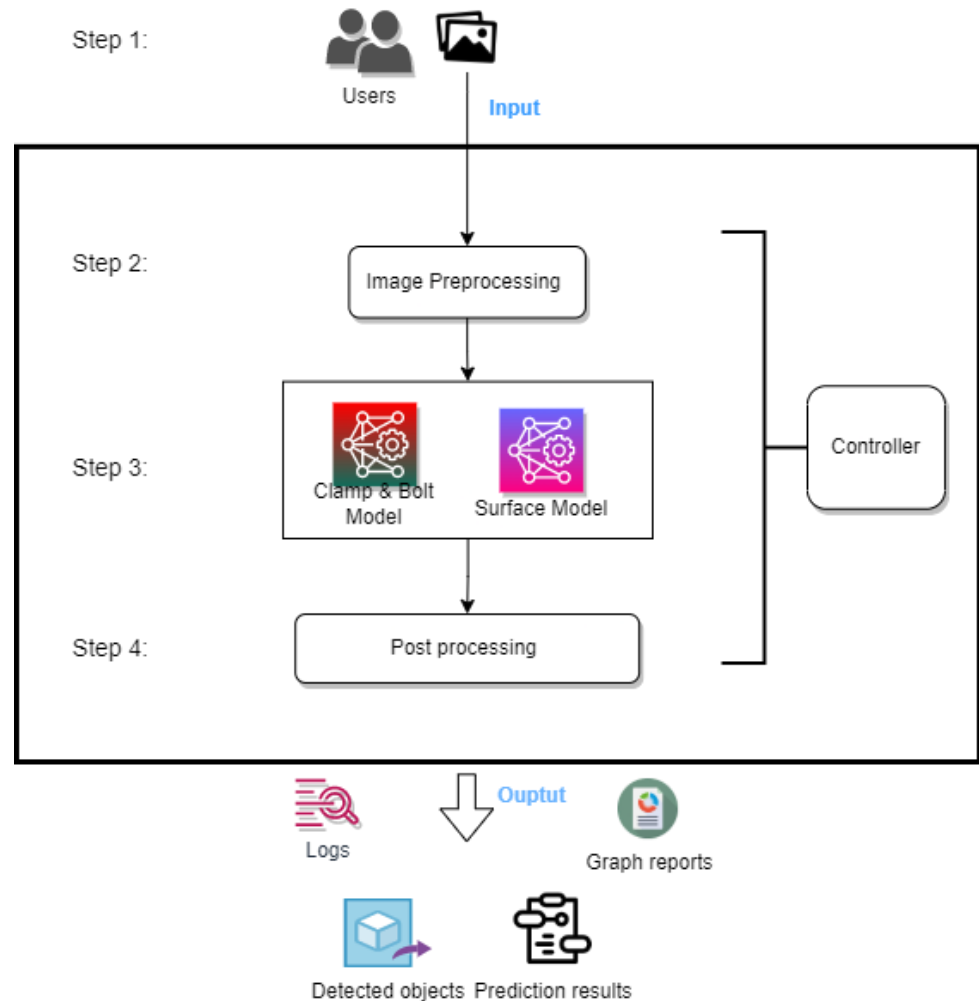
While YOLOv5 provides satisfaction result, there are also other models in our consideration for further experimentation



Prototype for defect  
detection  
on railway's fastener

## Eisenbahn Application

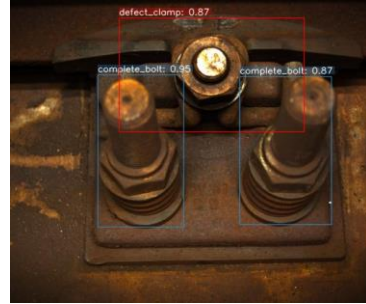
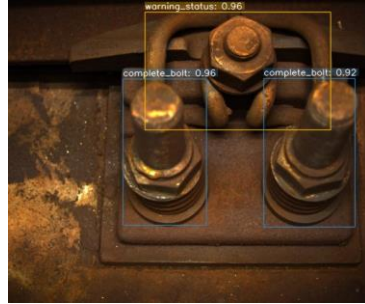
The framework is  
constructed specifically  
for inside-tunnel  
condition using AI image  
processing



# Defect fasteners



Artificial defects in real environment setting.



# Evaluation Report

- From our current evaluation on model with latest inspection data [**160,000 images**], we create a testing data set with 799 images
- The experiments were conducted on 2 scenarios under without and with image processing stage on input data

Prediction threshold = 0.5 , IOU 0.45

|                   | precision | recall | f1   |
|-------------------|-----------|--------|------|
| 0 (complete bolt) | 0.97      | 0.91   | 0.94 |
| 1 (defect bolt)   | 1         | 0.5    | 0.67 |
| 2 (defect clamp)  | 1         | 0.91   | 0.96 |
| 3 (normal clamp)  | 0.9       | 0.49   | 0.64 |
| 4 (warning bolt)  | 0.82      | 0.88   | 0.85 |
| 5 (warning clamp) | 0.64      | 0.96   | 0.77 |
| accuracy          |           |        | 0.84 |
| Macro avg.        | 0.85      | 0.75   | 0.78 |
| Weight avg.       | 0.86      | 0.84   | 0.83 |

Prediction threshold = 0.5 , IOU 0.45 + Image Preprocessing

|                   | precision | recall | f1   |
|-------------------|-----------|--------|------|
| 0 (complete bolt) | 0.87      | 0.98   | 0.92 |
| 1 (defect bolt)   | 1         | 1      | 1    |
| 2 (defect clamp)  | 0.98      | 0.94   | 0.96 |
| 3 (normal clamp)  | 0.85      | 0.78   | 0.81 |
| 4 (warning bolt)  | 0.78      | 0.90   | 0.83 |
| 5 (warning clamp) | 0.83      | 0.90   | 0.86 |
| accuracy          |           |        | 0.86 |
| Macro avg.        | 0.90      | 0.83   | 0.84 |
| Weight avg.       | 0.87      | 0.86   | 0.85 |

## Limitation:

- positive defect sample size might still be too small in defect bolt condition so improvement can be added in later retraining
- Standardize camera angle is still under study and might require adjustment on different environment

# Evaluation Report

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- If we remove under representation for defect class such as defect bolt [ Image size is reduced to 590 from removing redundancy and under-represent class]
- New reports can be made as following

Prediction threshold = 0.5 , IOU 0.45

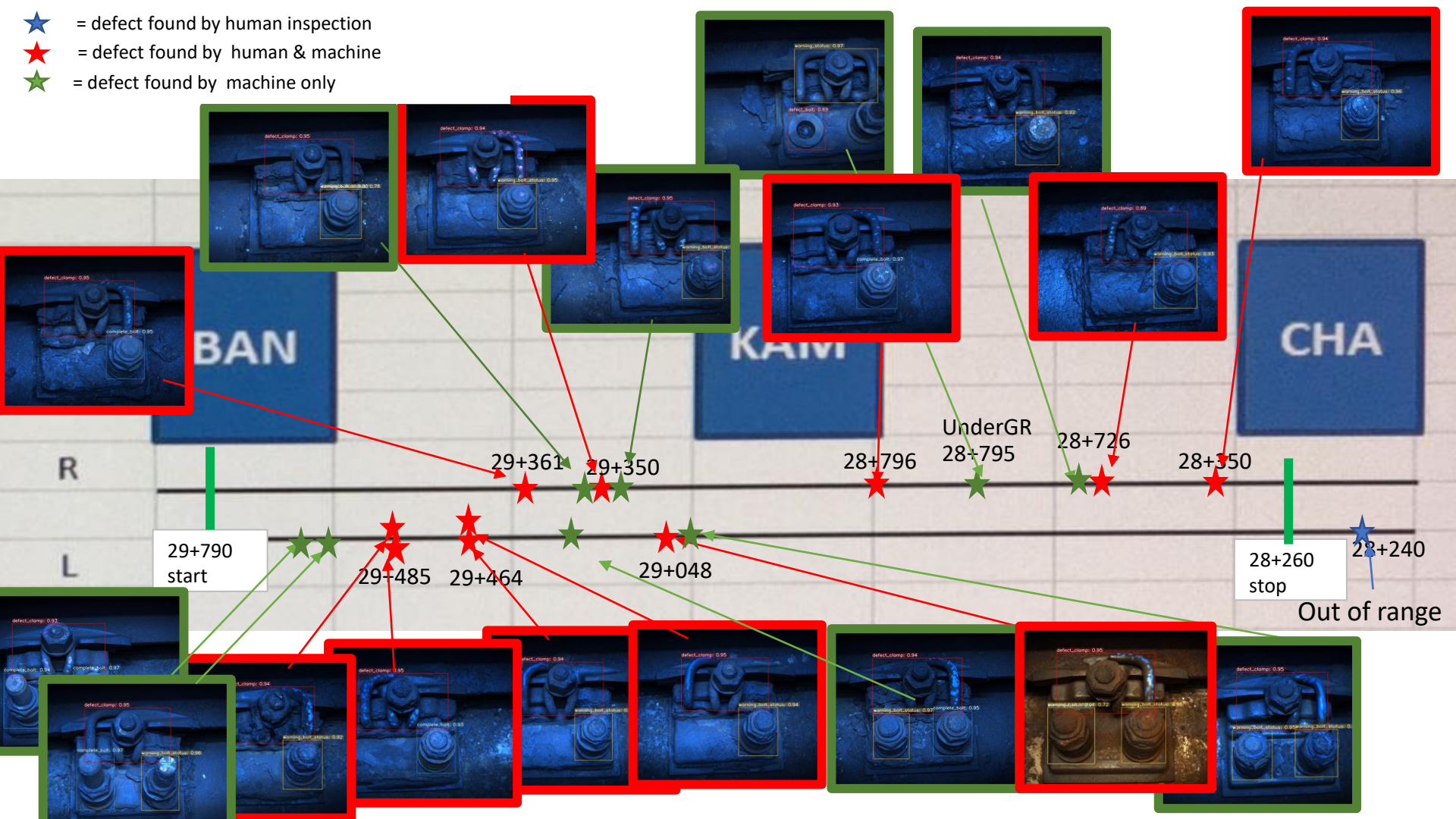
|                   | precision | recall | f1   |
|-------------------|-----------|--------|------|
| 0 (complete bolt) | 0.98      | 0.93   | 0.96 |
| 2 (defect clamp)  | 1         | 0.99   | 0.99 |
| 3 (normal clamp)  | 0.91      | 0.53   | 0.67 |
| 4 (waring bolt)   | 0.87      | 0.96   | 0.92 |
| 5 (warning clamp) | 0.76      | 0.95   | 0.85 |
| accuracy          |           |        | 0.91 |
| Macro avg.        | 0.91      | 0.87   | 0.88 |
| Weight avg.       | 0.92      | 0.91   | 0.91 |

Prediction threshold = 0.5 , IOU 0.45 + Image Preprocessing

|                   | precision | recall | f1   |
|-------------------|-----------|--------|------|
| 0 (complete bolt) | 0.95      | 0.98   | 0.96 |
| 2 (defect clamp)  | 0.99      | 0.99   | 0.99 |
| 3 (normal clamp)  | 0.94      | 0.79   | 0.86 |
| 4 (waring bolt)   | 0.95      | 0.92   | 0.94 |
| 5 (warning clamp) | 0.89      | 0.95   | 0.92 |
| accuracy          |           |        | 0.94 |
| Macro avg.        | 0.94      | 0.92   | 0.93 |
| Weight avg.       | 0.94      | 0.94   | 0.94 |



- ★ = defect found by human inspection
- ★ = defect found by human & machine
- ★ = defect found by machine only



Thank you