



iNFRA

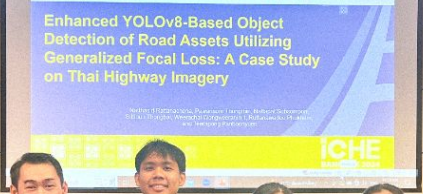


Chula
Chulalongkorn University

Enhanced YOLOv8-Based Object Detection of Road Assets Utilizing Generalized Focal Loss: A Case Study on **Thai Highway** Imagery

Teerapong Panboonyuen

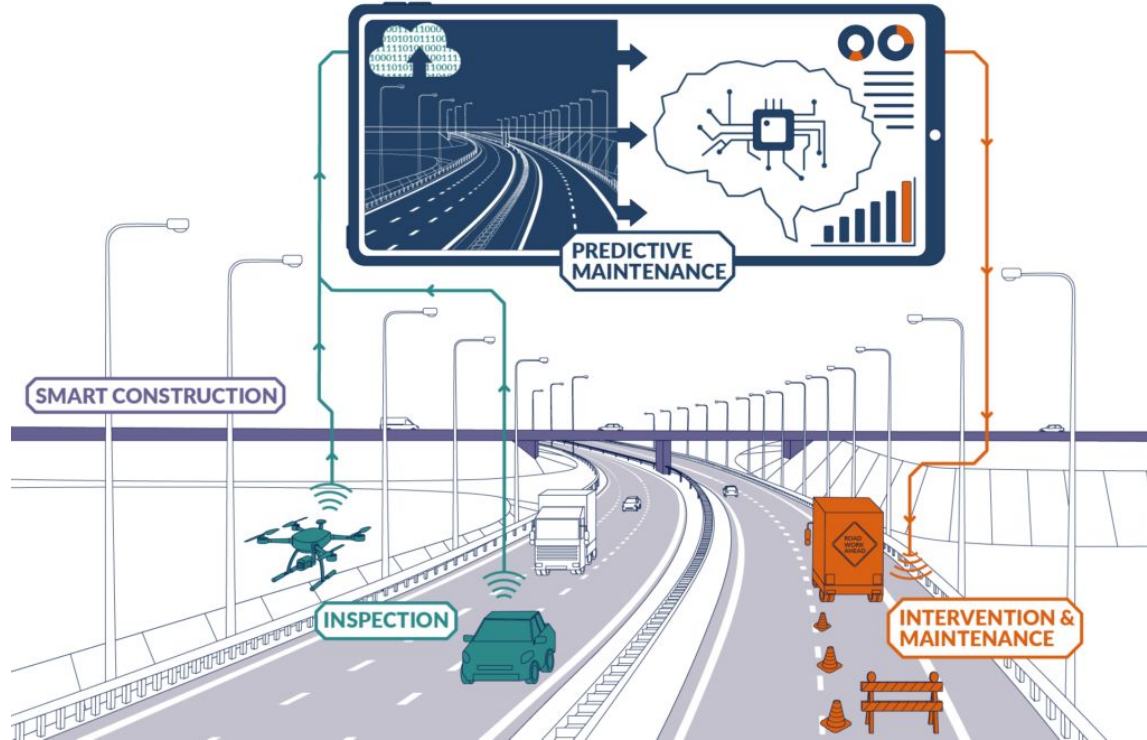
<https://kaopanboonyuen.github.io/>



Refined Generalized Focal Loss for Road Asset Detection on Thai Highways Using Vision Models



Overview of Object Detection of Road Assets



Motivation | "Why Road Asset Management Matters?"



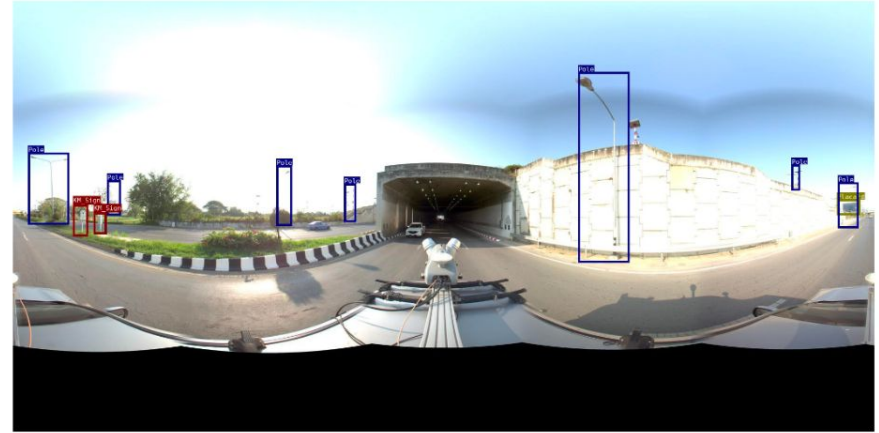
Related Work

Panboonyuen, T.; Thongbai, S.; Wongweeranimit, W.; Santitamnont, P.; Suphan, K.; Charoenphon, C. Object Detection of Road Assets Using Transformer-Based YOLOX with Feature Pyramid Decoder on Thai Highway Panorama. Information 2022, 13, 5.

<https://doi.org/10.3390/info13010005>



(a)

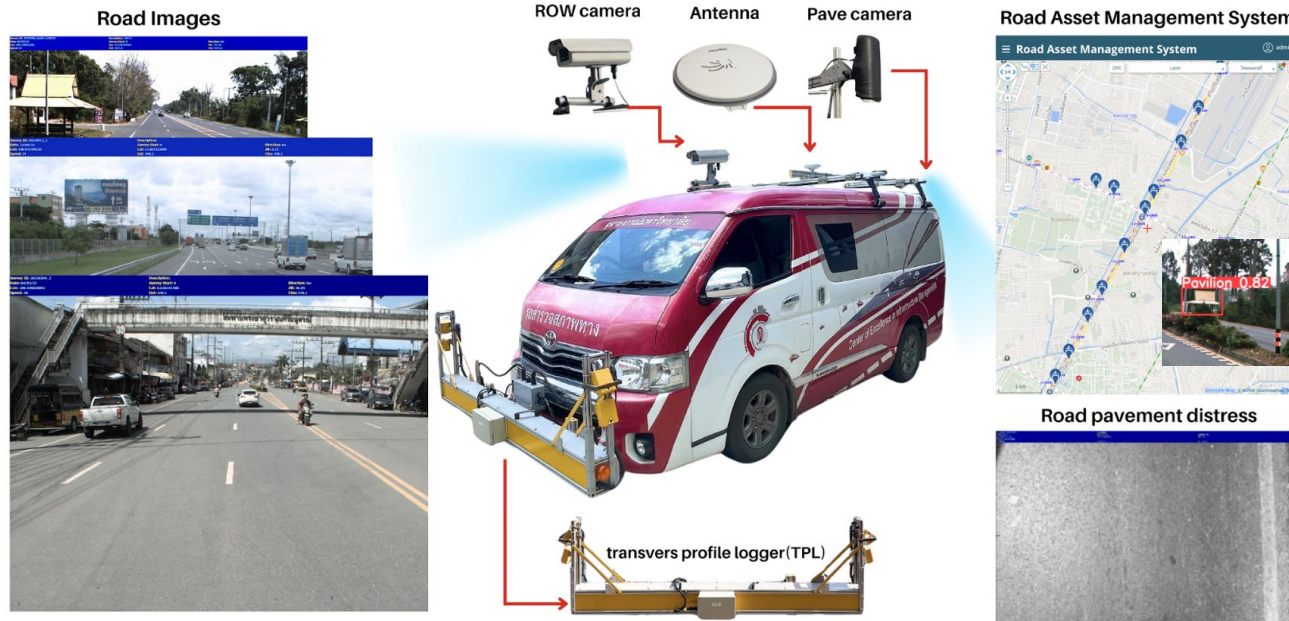


(b)

Figure 1. The challenges in the Road Asset corpus. Sample of input image (a) and target image (b).

A Vehicle Equipped with Cameras (Our Contribution)

Self-Created Datasets: The Backbone of Our Approach



A Vehicle Equipped with Cameras (Our Contribution)

Self-Created Datasets: The Backbone of Our Approach

- The images were captured using the ZBR2-PGEHD-20S4C color camera, featuring a high-sensitive Sony ICX274 CCD sensor. Key specifications of the camera are as follows:
 - Model: ZBR2-PGEHD-20S4C Color 2.0 MP
 - Sensor: Sony ICX274 CCD, size 1/1.8
 - Shutter: Global Shutter
 - Resolution: 1624 x 1224 at 30 FPS (HD-SDI 25 FPS)
 - Interfaces: HD-SDI (2.97 Gbs/s) and GigE Vision (1000Mb/s, PoE)
 - Frame Rates: 2.0 MP at 30 FPS and 5.0 MP at 15 FPS

Dataset Overview

Total Images:

- **Training:** 1,994
- **Validation:** 1,418

Resolution: 640x640 pixels

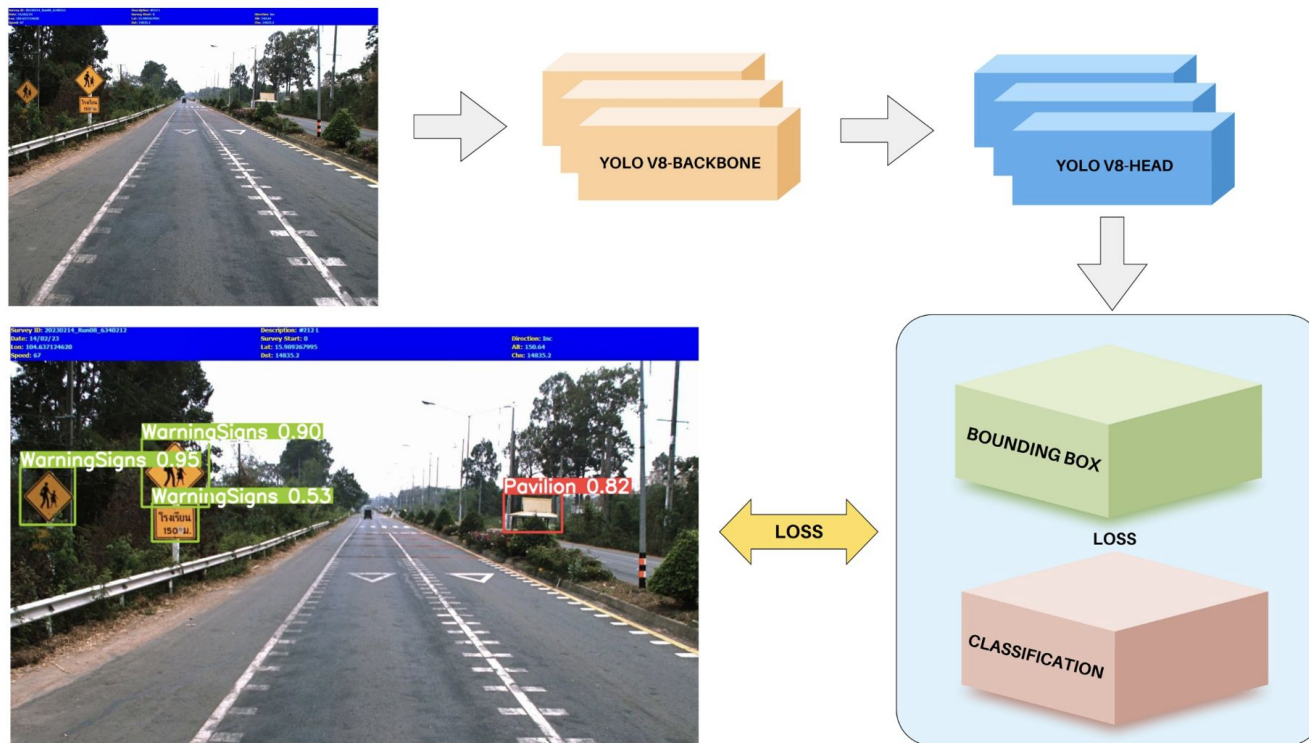
Source: Thai highway panoramas

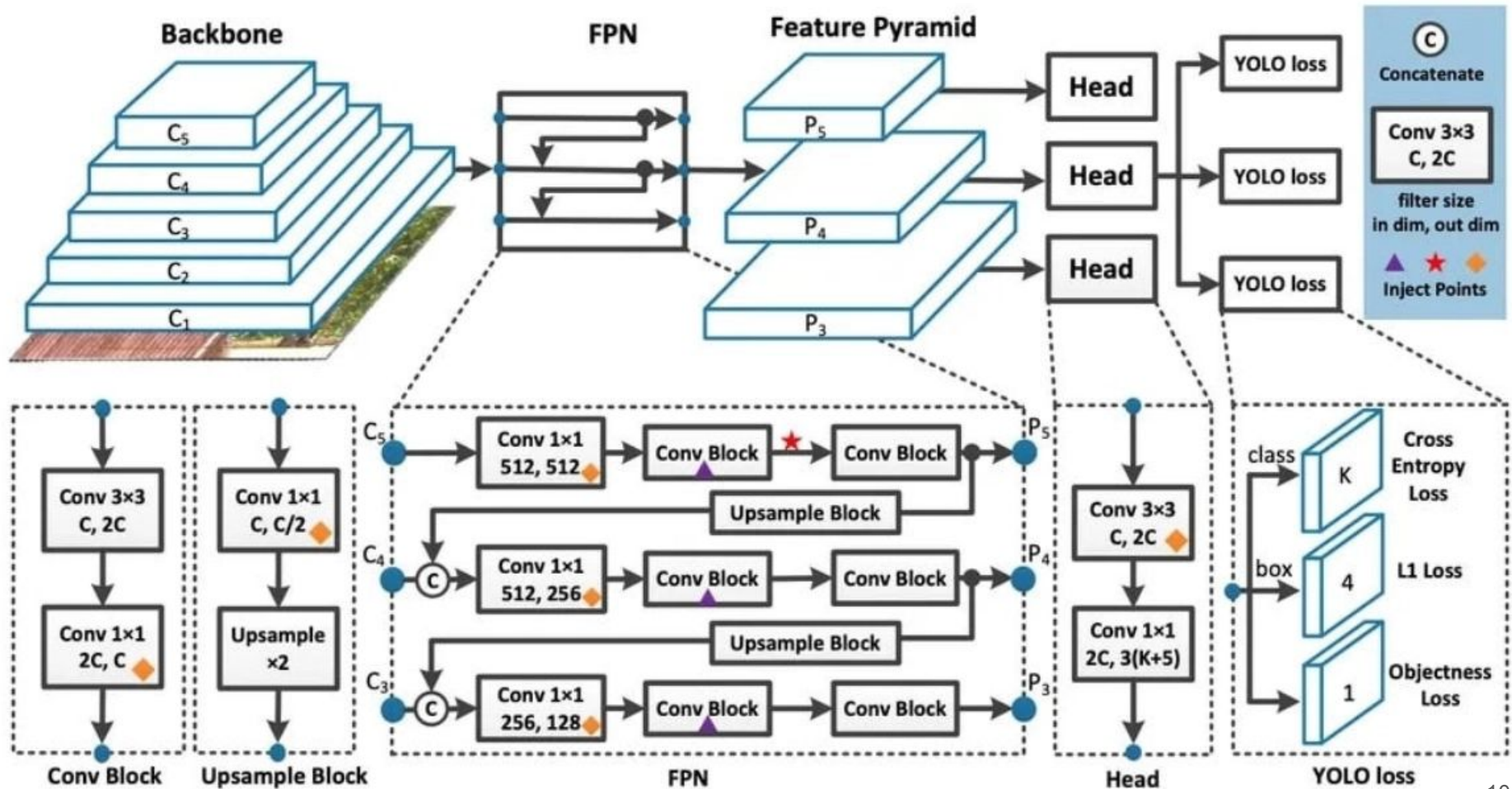
Capture Method: Mounted camera on Chulalongkorn University van

Annotations

- **Detection Tasks:** 7 classes
 - Pavilions
 - Pedestrian bridges
 - Information signs
 - Single-arm poles
 - Bus stops
 - Warning signs
 - Concrete guardrails
- **Segmentation Tasks:** 5 classes
 - Pavilions
 - Pedestrian bridges
 - Information signs
 - Warning signs
 - Concrete guardrails

Enhanced YOLOv8-Based Object Detection





Generalized Focal Loss

Formula:

$$\text{GFL}(p_t) = -\alpha_t(1 - p_t)^{\gamma_1} \log(p_t) - \beta_t p_t^{\gamma_2} \log(1 - p_t)$$

Why Generalized Focal Loss?

- **Adaptability:** Tailors focus on easy and hard examples by adjusting two parameters, γ_1 and γ_2 .
- **Enhanced Class Imbalance Handling:** Provides better control over class imbalance compared to traditional Focal Loss.
- **Improved Detection Performance:** Balances precision and recall more effectively across diverse object detection scenarios.

Why Not Use Traditional Focal Loss?

Limitations of Focal Loss:

- **Fixed Focus:** Focal Loss uses a single gamma parameter, which limits its ability to balance between easy and hard examples.
- **Rigid Handling of Class Imbalance:** It provides less flexibility in managing different degrees of class imbalance, which can affect detection performance.
- **Over-Suppression of Easy Examples:** Sometimes over-focuses on hard examples, leading to under-training on easy examples, which can reduce overall model accuracy.

Comparison of Detection Methods

Model	mAP50	mAP50-95	Precision	Recall	F1 Score
YOLOv8n	71.100	47.760	80.100	63.460	70.820
YOLOv8s	75.150	52.070	82.660	69.950	75.780
YOLOv8m	79.570	58.060	85.410	71.290	77.710
YOLOv8l	80.270	59.110	82.580	77.220	79.810
YOLOv8x	80.340	60.840	79.100	76.680	77.870

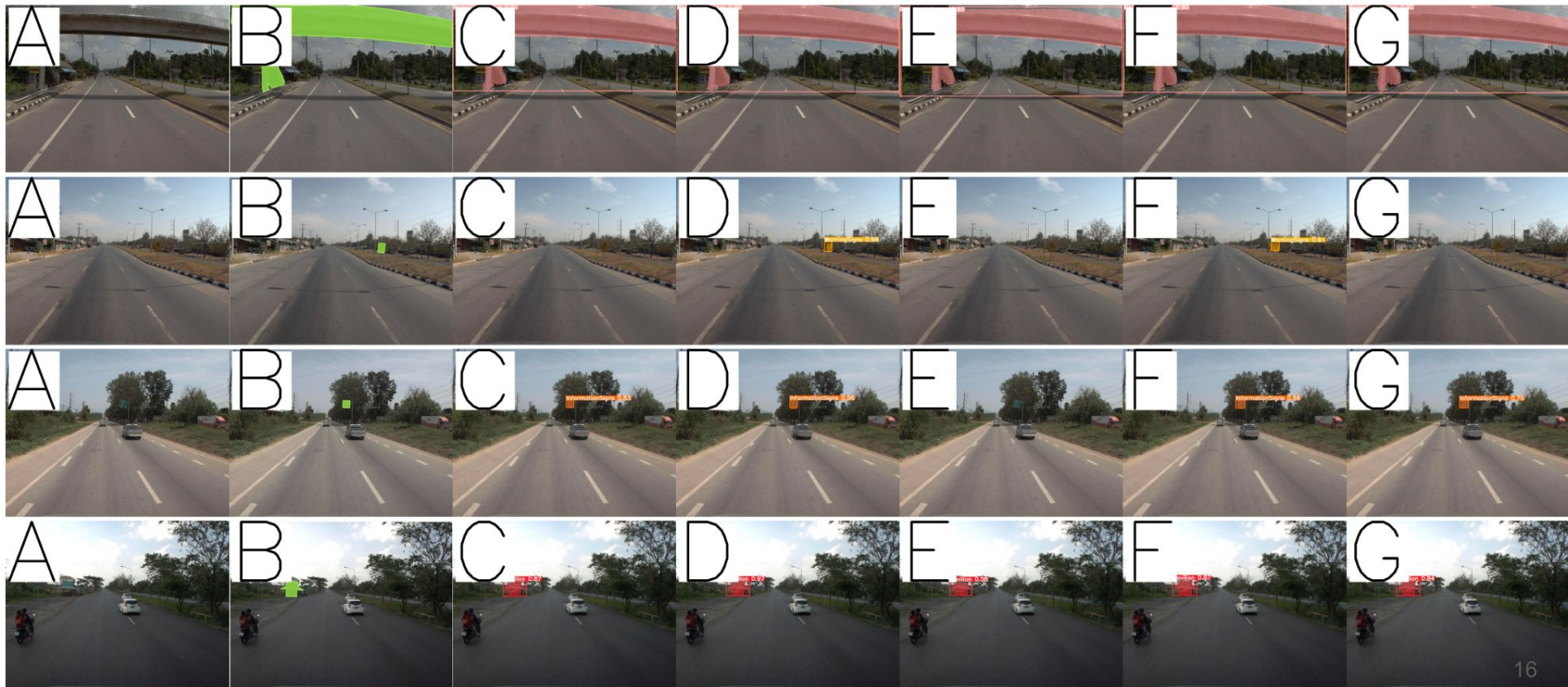
(a) Input, (b) Target, (c) YOLOv8n, (d) YOLOv8s, (e) YOLOv8m, (f) YOLOv8l, and (g) YOLOv8x, with (f) and (g) representing our proposed method.



Comparison of Segmentation Methods (Masks)

Model	mAP50	mAP50-95	Precision	Recall	F1 Score
YOLOv8n	81.40	53.27	89.36	71.79	79.62
YOLOv8s	90.08	63.88	88.78	86.09	87.41
YOLOv8m	74.01	44.39	78.88	68.51	73.33
YOLOv8l	79.30	51.50	87.10	72.20	78.95
YOLOv8x	83.24	53.48	85.72	78.36	81.87

(a) Input, (b) Target, (c) YOLOv8n, (d) YOLOv8s, (e) YOLOv8m, (f) YOLOv8l, and (g) YOLOv8x, with (f) and (g) representing our proposed method.



Conclusion and Q&A

- Enhanced detection with YOLOv8 and Generalized Focal Loss
- Significant improvements in accuracy and robustness
- Broad applicability and future potential
- Future research directions:
 - Real-time deployment
 - Further model optimizations

