MINISTRY OF ECONOMY
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AL-SULTAN ABDULLAH

Pusat
Sains Matematik

Development of a Cloud-Based Road Surface Quality Assessment System

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11Th MALAYSIA STATISTICS CONFERENCE
"Data and Artificial Intelligence: Empowering the Future"

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INTRODUCTION

High-quality road surfaces are essential for safety and economic well-being.

In 2023, Malaysia recorded approximately 600,000 road accidents, resulting in 6,443 fatalities—equivalent to an average of 18 deaths per day.

A study by the Malaysian Institute of Road Safety Research (MIROS) found that road accidents were mainly caused by human behavior, followed by the design, condition of road infrastructure, and vehicles' condition.

There is still a potential to reduce the number of road accidents and injuries by improving road surfaces, thereby fostering sustainable cities and communities.

Key: Road deaths per 100,000 people; Road quality score /7; Traffic level; Seatbelt wearing percentage; Attribution of road traffic deaths to alcohol; Max speed limit in towns (kph); Motorway speed limit (kph); Road safety score /10

	Country	Road deaths per 100,000 people	Road quality score /7	Traffic level	Seatbelt wearing percentage	Attribution of road traffic deaths to alcohol	Max speed limit in towns (kph)	Motorway speed limit (kph)	Road safety score /10
1	Netherlands	3.98	6.4	89.4	96%	11%	50	130	7.86
2	Norway	2.12	4.5	92.6	95%	13%	50	110	7.47
3	Sweden	3.14	5.3	98.2	97%	24%	50	120	7.42
3	Estonia	4.46	4.7	84	95%	10%	50	120	7.42
5	Spain	3.91	5.7	105.2	88%	12%	50	120	7.20
6	United Kingdom	3.21	4.9	133.8	98%	13%	48	112	7.09
6	Finland	3.89	5.3	82.6	94%	24%	50	120	7.09
8	Iceland	2.05	4.1	88.9	90%	14%	50	90	7.03
9	Germany	3.78	5.3	105.1	98%	7%	50	447	6.98
10	Japan	3.60	6.1	133.7	95%	6%	60	120	6.71
11	Luxembourg	4.07	5.5	108.9	92%	14%	50	130	6.21
11	Portugal	8.20	6.0	110.9	95%	29%	50	120	6.21
13	Lithuania	8.14	4.8	89.6	94%	10%	50	130	6.16
14	Israel	3.91	4.9	154.1	88%	4%	50	120	6.15
15	Croatia	7.95	5.6	96.1	58%	24%	50	130	5.38
15	Ireland	3.13	4.4	149.5	91%	39%	50	120	5.11
17	Chile	14.91	5.2	128.2	50%	13%	50	120	4.95
18	Hungary	7.74	4.0	126	81%	7%	50	130	4.84
19	Slovenia	5.05	4.9	99.2	82%	32%	50	130	4.78
20	Poland	9.38	4.3	114.4	94%	13%	50	140	4.34
21	Canada	5.34	5.0	140.1	95%	30%	80	120	4.29
22	Serbia	7.47	3.5	111.7	66%	17%	50	130	4.18
23	Malaysia	22.48	5.3	168.4	48%	0%	60	110	4.07
24	Mexico	12.78	4.5	175.4	59%	20%	50	110	3.96
25	Greece	8.31	4.6	133.1	72%	25%	50	130	3.85
26	United States	12.67	5.5	152.2	90%	29%	89	137	2.53
27	Argentina	14.06	3.6	175	44%	17%	60	130	1.65

Common Road Surface Defects

Potholes

Causes: Water infiltration, freeze-thaw cycles, and traffic wear.

Impact: Vehicle damage and safety hazards.

Fatigue Cracking (Crocodile Cracking)

Structural vulnerabilities due to continuous pressure from heavy vehicles.

Aging effects exacerbate road integrity issues.

INTRODUCTION

- Technological Solutions
  - **Mobile Crowdsensing (MCS)**
    - Leverage smartphone sensors for cost-effective road quality assessment.
    - Widespread smartphone usage enables efficient data collection.
  - Advanced Technologies
    - Integration of lasers, cameras, sensors, and cloud-based monitoring..
    - Initial investment pays off in accuracy and real-time insights.

OBJECTIVES

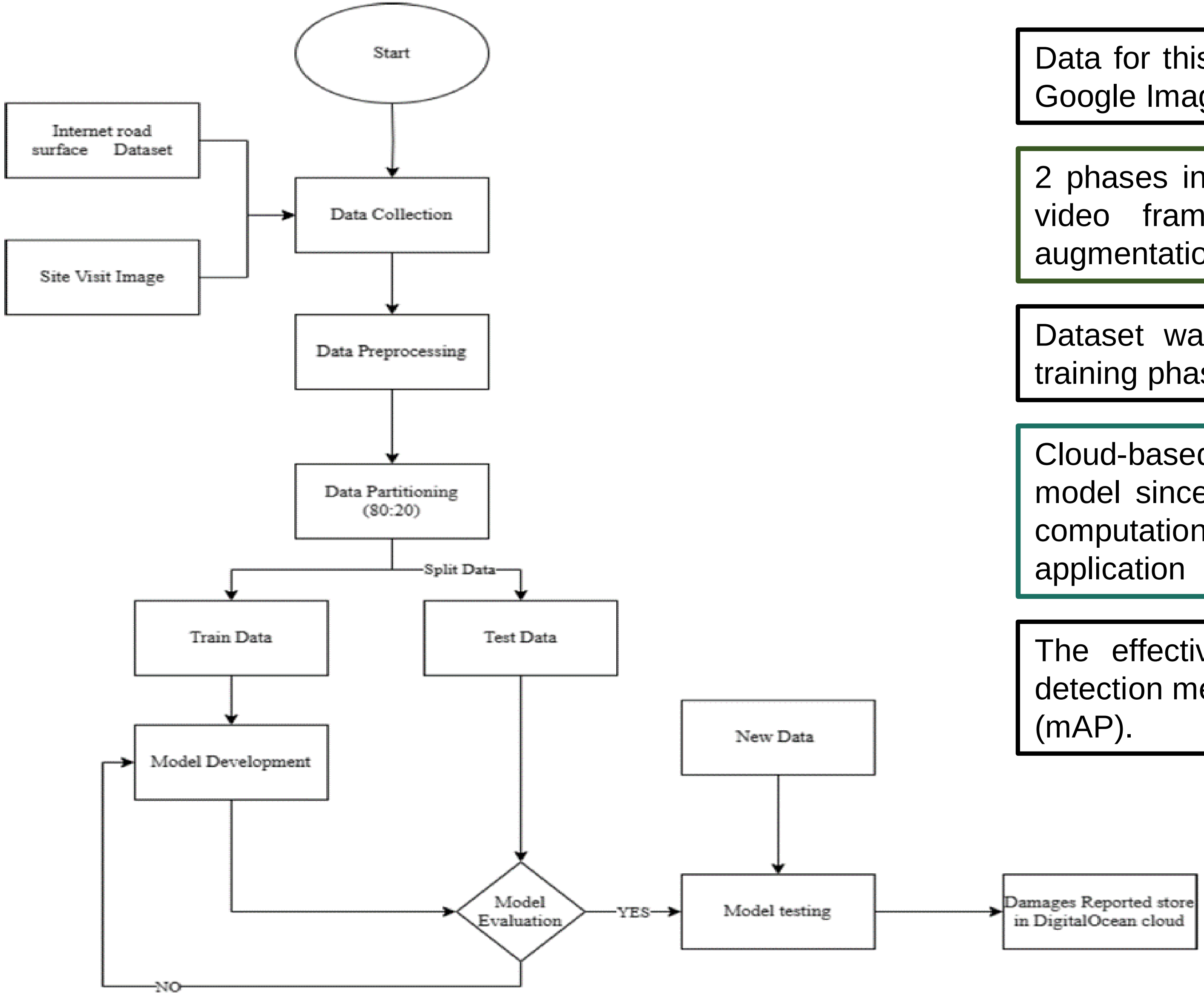
1. To design a cloud-based architecture that can process and respond numerous of data in a short period of time by applying Digital Ocean cloud services.

2. To identify road surface quality defections effectively by using of YOLO.

3. To develop a cost-effective system that optimizes accuracy for real-time processing by implementing data augmentation, and confusion matrix-based evaluation approach.

Developing a cloud-based road surface quality assessment system ensures safer and more reliable transportation infrastructure for all.

METHODOLOGY



Data for this study was collected from site visits and the Internet, such as Google Images.

2 phases in data preprocessing: video preprocessing (frame resizing and video frame extraction) and image preprocessing (labelling, data augmentation, and image resizing).

Dataset was partitioned into two subsets: 80% (6400 images) for the training phase and 20% (1600 images) for testing

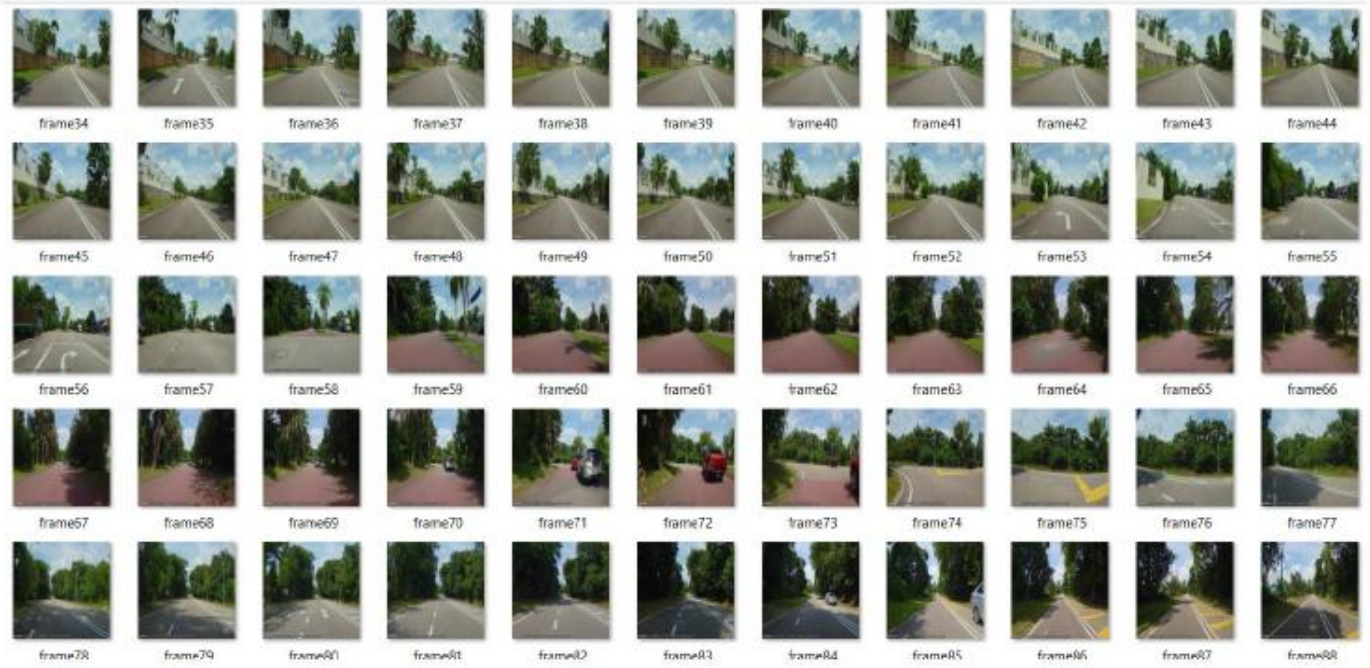
Cloud-based road surface quality assessment system using the YOLOv8 model since it is well-suited for use in a cloud-based system, where the computational resources can be scaled to meet the demands of the application

The effectiveness of the model was assessed using common object detection metrics, such as precision, recall, and the average mean precision (mAP).

RESULTS

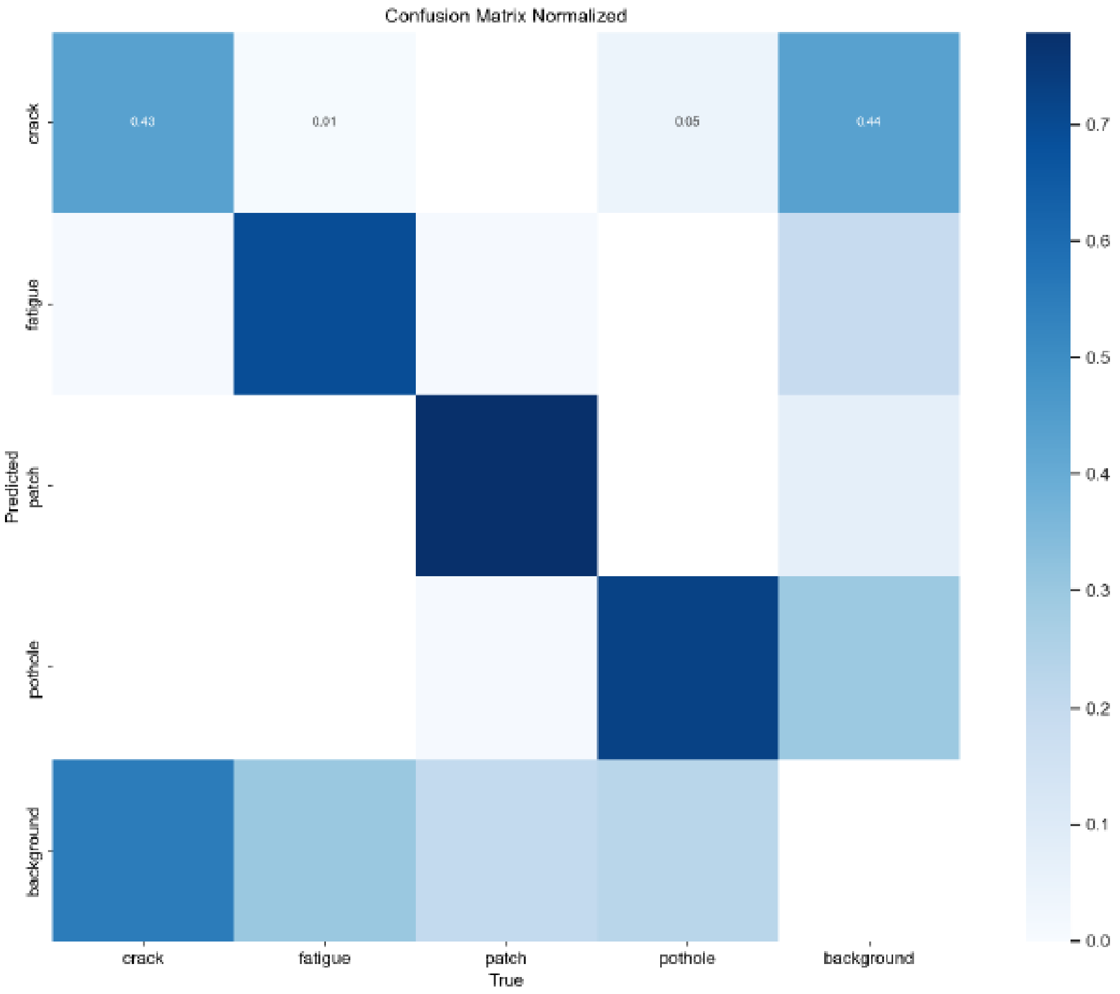
Video Recorded using Dashcam

Extracted video frames by using Python

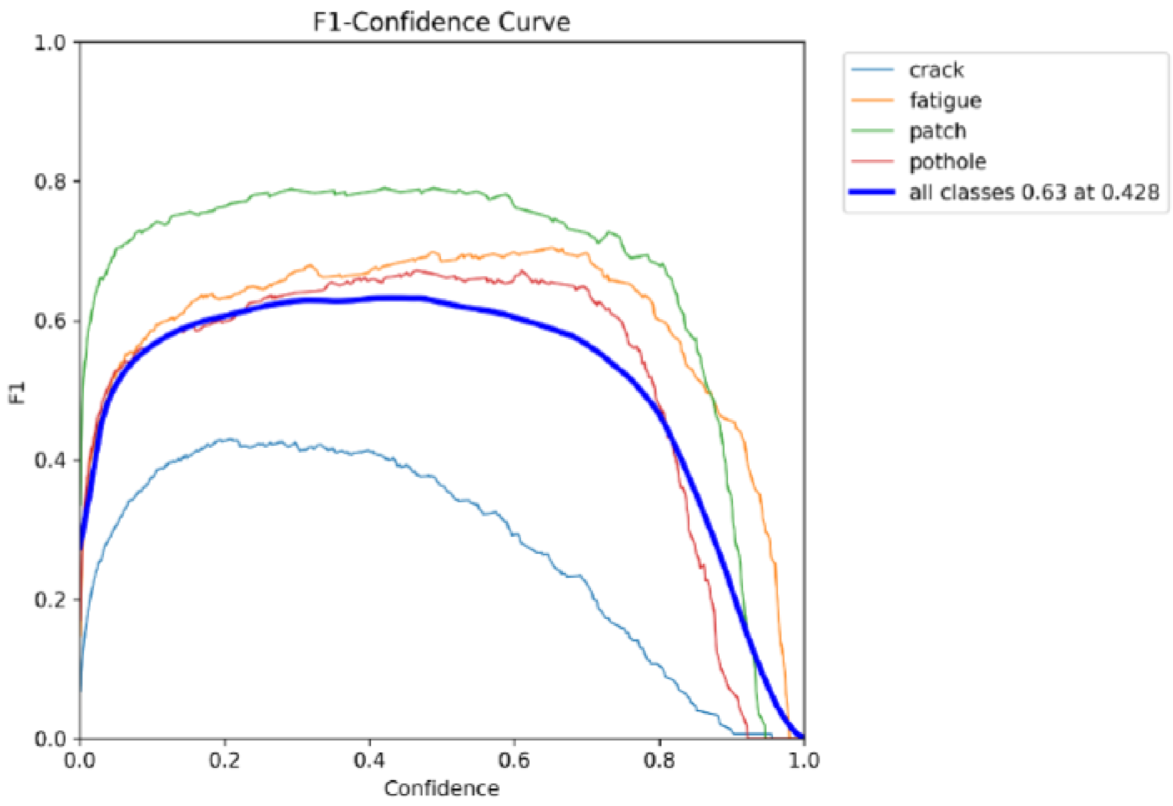


Results of preprocessing

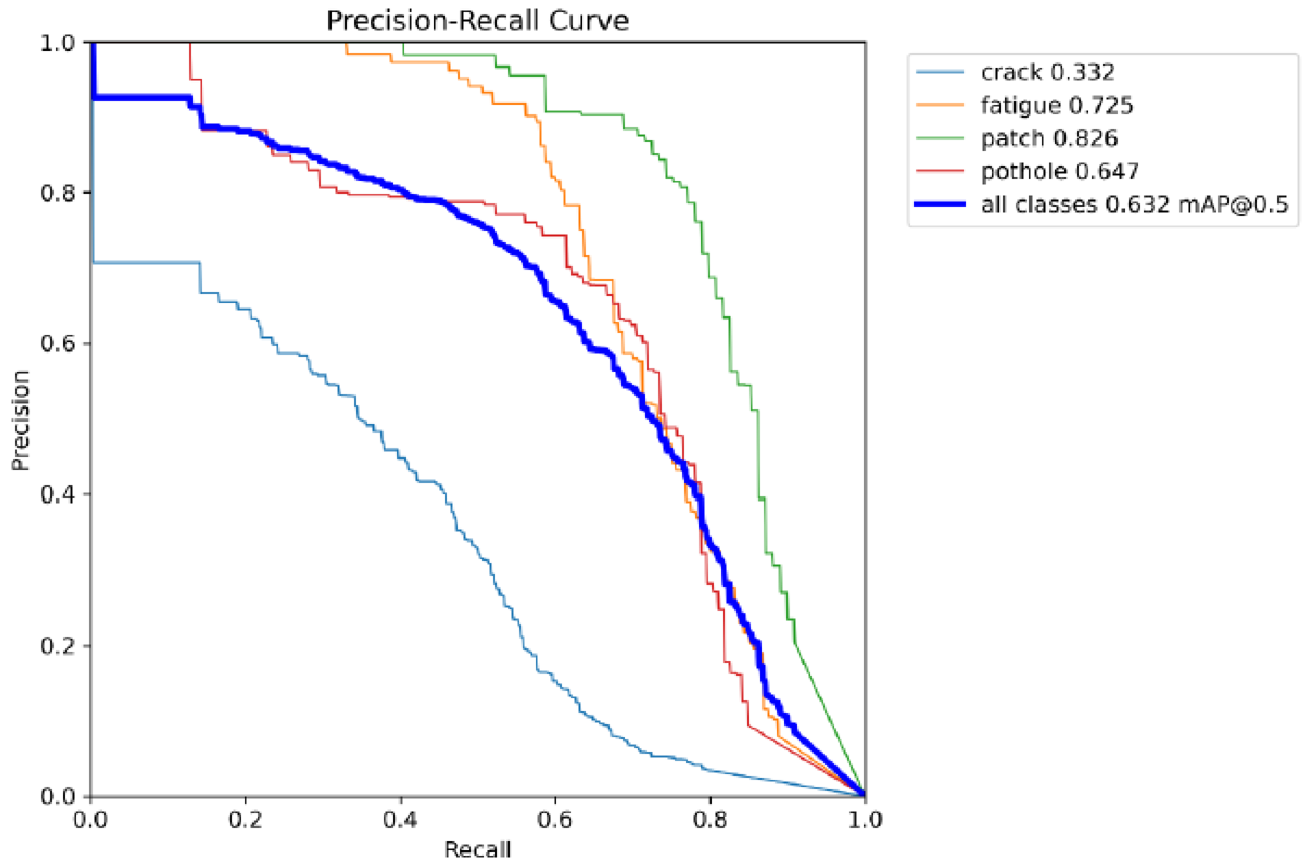
The number of epochs for model development was 200, and the batch size was 16. By default, the model training will trigger early stopping if there is no improvement in the last 50 epochs to avoid overfitting; thus, this model stopped at epoch 153. The best result was obtained at epoch 103.



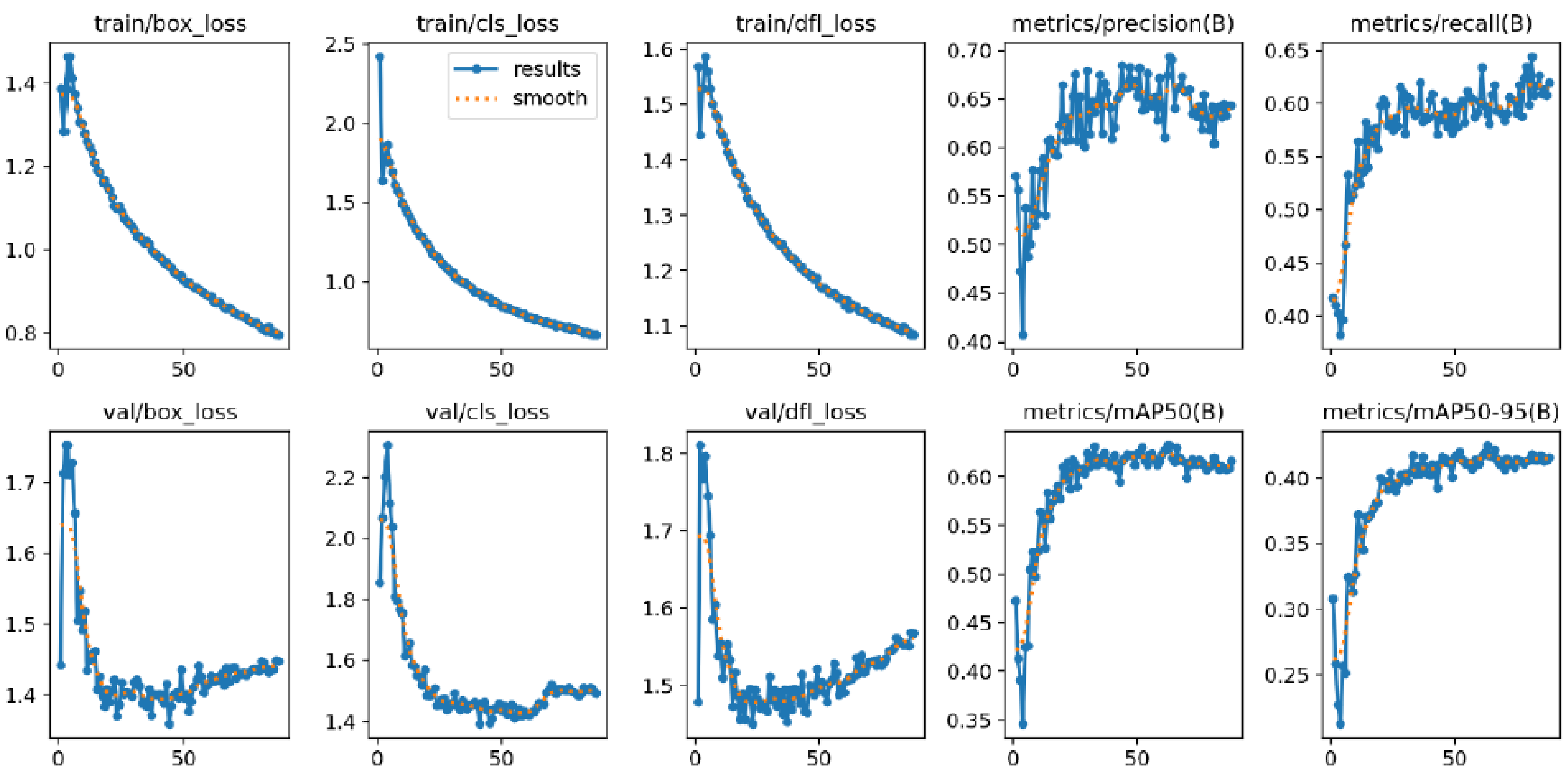
Confusion matrix



F1-score curve



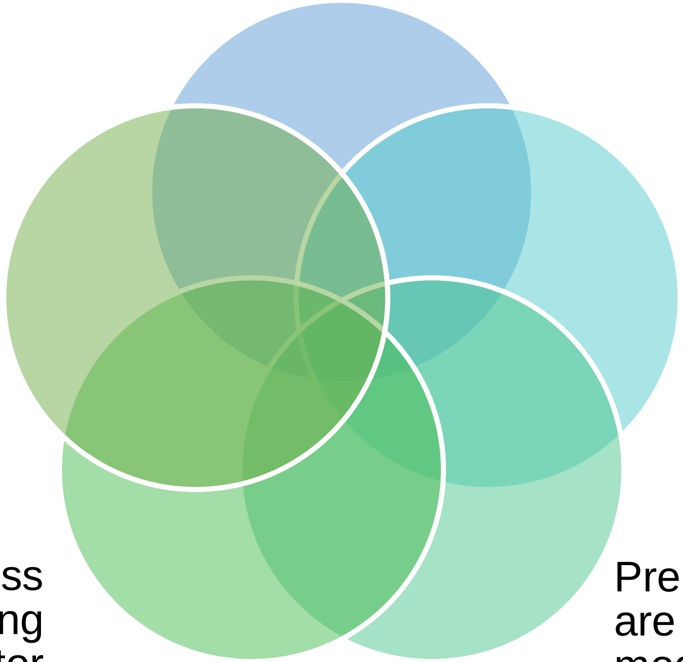
Precision versus Recall curve



Overall Results for YOLOv8 Model Training

The model’s speed: it takes 0.7 milliseconds (ms) for preprocessing, 7.5 ms for inference, 0.0 ms for loss computation, and 1.5 ms for postprocessing per image.

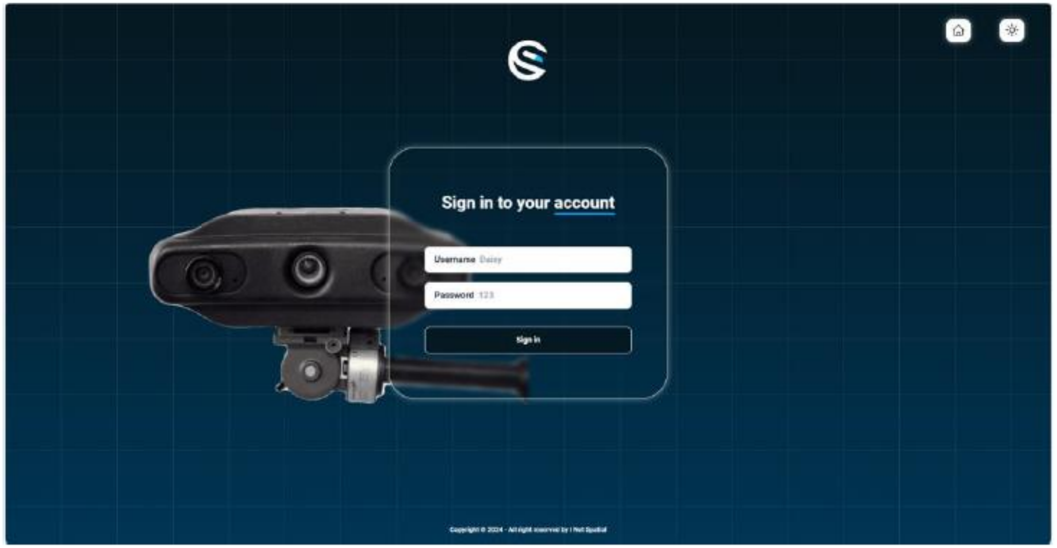
This efficient processing is a key feature for road anomaly detection in dashcam footage applications, instilling confidence in the model’s applicability

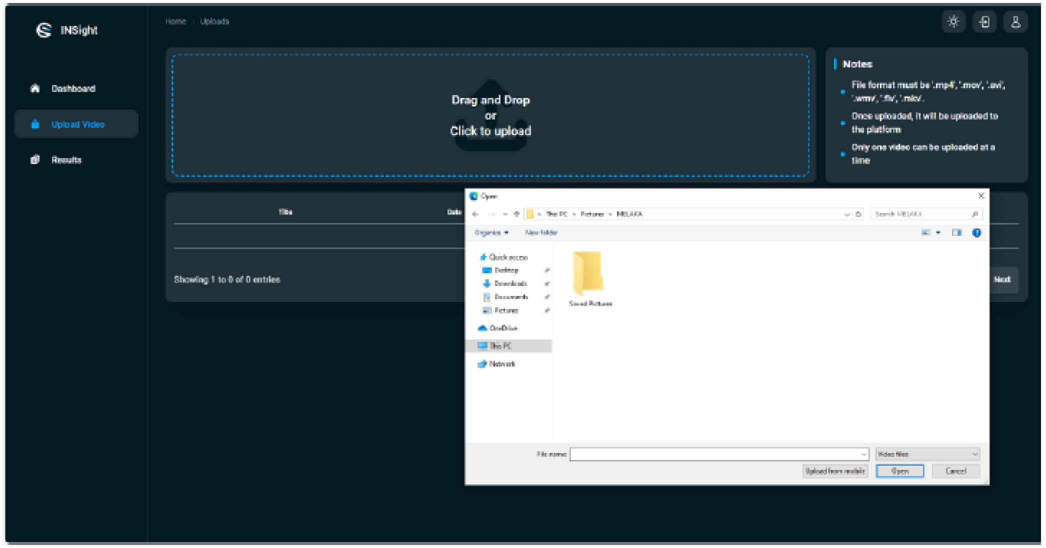


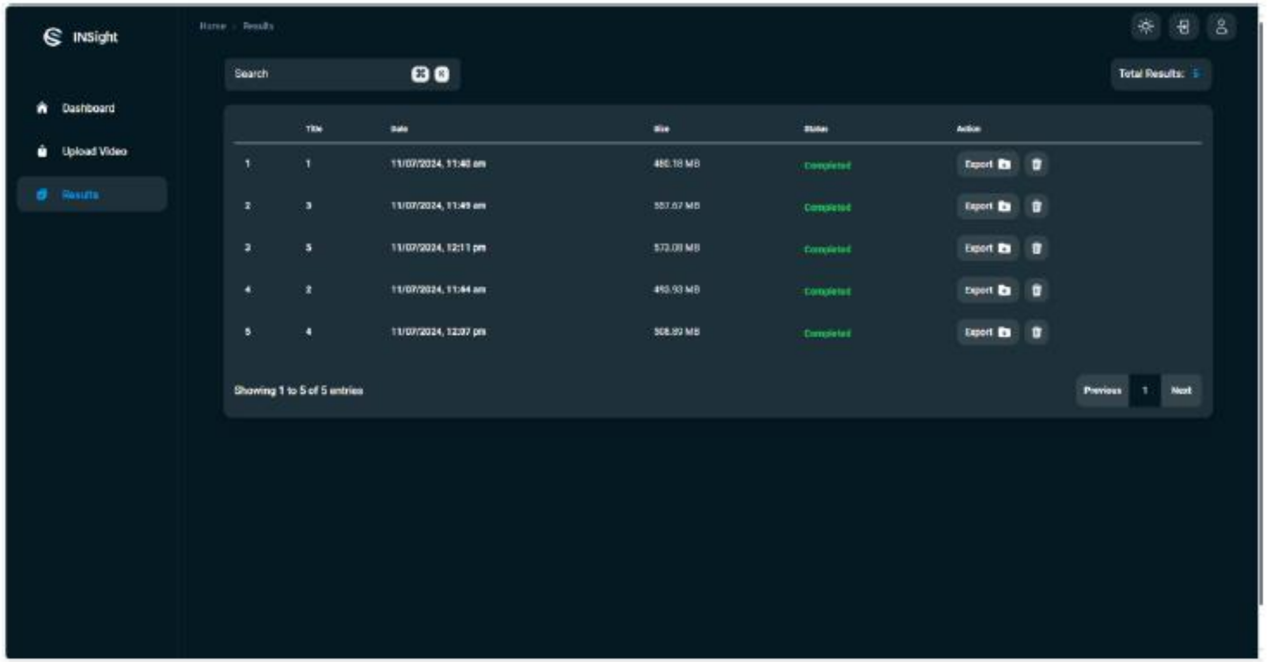
This breakdown underscores that the model is optimized for real-time or near-real-time analysis, with the majority of the processing time dedicated to inference, the task of detecting objects in the image.

The 0.0 ms loss time confirms that loss computation, typically used during training to optimize the model, is not a factor during the evaluation phase.

Preprocessing and postprocessing times are relatively minimal, suggesting that the model efficiently prepares the data for analysis and processes the results.







Results based on file uploaded using DigitalOcean cloud

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CONCLUSION

This study aims to make road defect detection faster, more accurate, and cost-effective.

We used GIS technology and a deep learning model to accurately locate and classify road surface defects.

Our dataset included 4,000 images collected from various sources. We employed a pre-trained model to detect and classify defects and assessed its accuracy.

Our method could significantly benefit local government departments and enhance public safety by enabling timely and reliable identification of road surface defects.

This research has the potential to improve road safety and reduce maintenance time, contributing to public safety and overall road conditions.

Thank you!