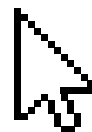




Capstone Project



TheiaVision: Object Detection
Technology for PMD Safety Alerts



Ng Wei GA-DSI-42 14-May-2024



I am from

Innovation and Design Team

in MaximalSG (PMD Maker)



You are Darren

Management Team

in MaximalSG (PMD Maker)



Content

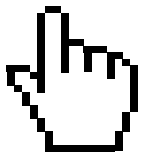
01 Problem Statement & Persona

02 Dataset & Preprocessing

03 Data Modelling & Hyperparameter tuning

04 Demonstration

05 Conclusion & Recommendations





01

Problem Statement & Persona





Articles of PMD

Oct
2019

“TTSH reports spike in **injuries involving PMD riders”**

In 2019, PMD accident rate increased **68%** from 2017

Source: [The Strait Times](#)

Nov
2019

“E-Scooters to Be Prohibited on All Footpaths Following Safety Review”

Source: [LTA](#)

2020 -
2022

“PMD-related offences decrease in last 3 years as e-scooter population dwindles further”

From 2020 to 2022, **65%** fall in PMD-related offences

Source: [The Strait Times](#)

May
2022

“PMD delivery rider **dies after accident with motorcycle in Serangoon”**

Source: [The Strait Times](#)



PMD Accident Footage





PMD Accident Footage





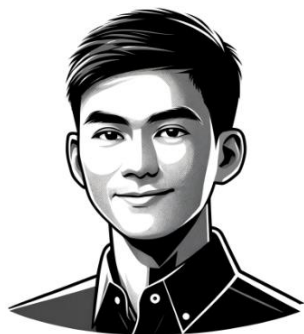
Problem Statement

How can we **enhance the safety of Personal Mobility Devices (PMDs)** in urban environments by using **object detection** to improve PMD users' ability to perceive and respond to their surroundings?





Persona



Darren

36

Product Manager
MaximalSG (PMD)

Darren is addressing the critical challenge of **enhancing PMD safety** due to increasing urban accidents. He is leading the development of an alert system with **object detection technology** that identifies obstacles such as **pedestrians, vehicles, and traffic signs**.





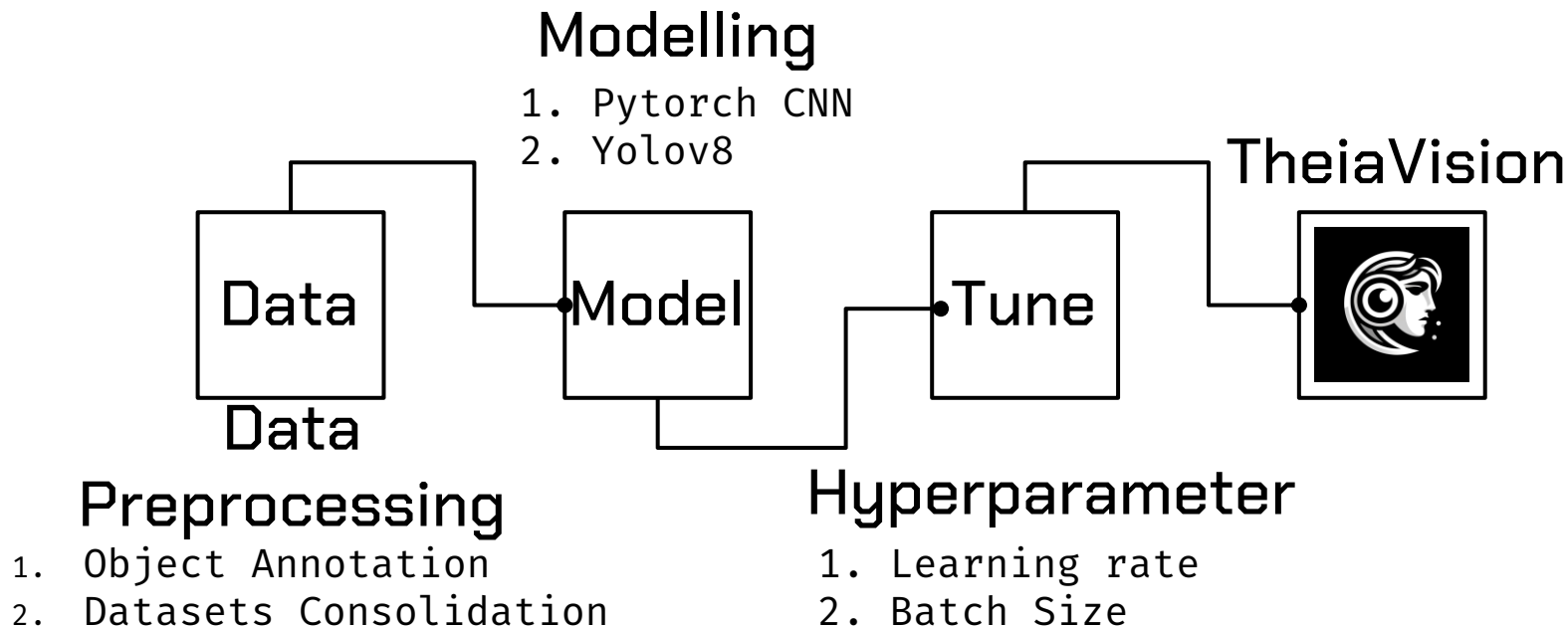
The Solution -TheiaVision



TheiaVision – An Eye of PMD that
guide your way!



What is behind of TheiaVision?





02

Dataset & Preprocessing



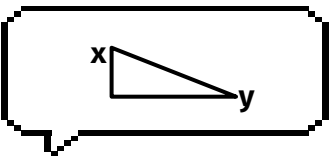


Image Dataset



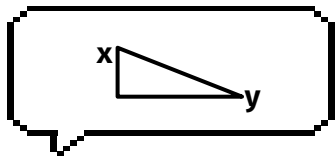
	Udacity Self Driving Car	Singapore Traffic Sign
Images	15,000 images	851 images
Annotation	97,942 labels	Unlabelled
No. of Class	12	7
Resolution	512 x 512 Pixels	Not fixed Pixel, Low Resolution
Content	Car, pedestrian, truck and traffic lights	7 traffic signs related with PMD/Pedestrian
Sources	 roboflow	
Readiness	Ready for modelling	Raw images





Image Dataset



Udacity Self Driving Car

Singapore Traffic Sign

Images	15,000 images	851 images
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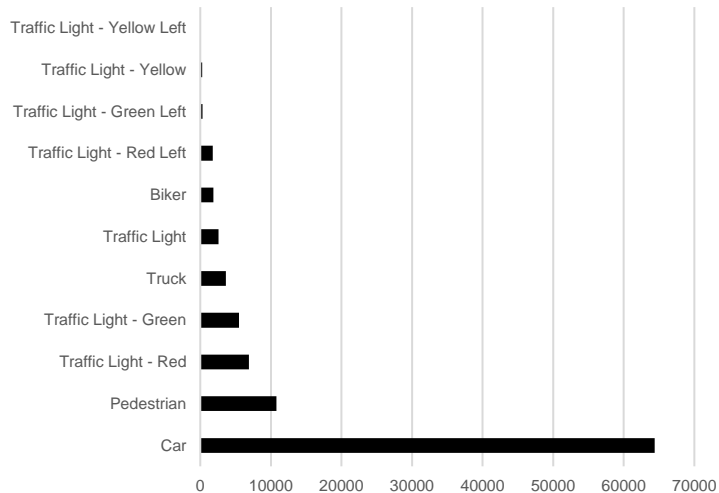
Label/Image Proportion



roboflow

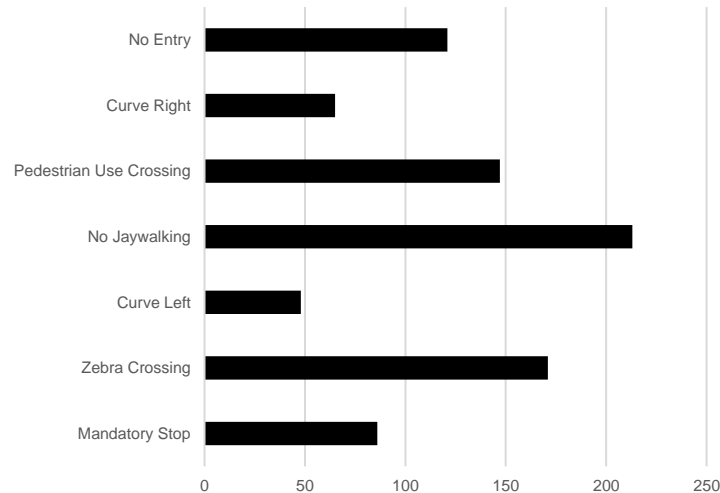
Udacity Self Driving Car

Label Frequency



Singapore Traffic Sign

Image Frequency





You've found the secret 'EDA' level



02.01

Singapore Traffic Sign

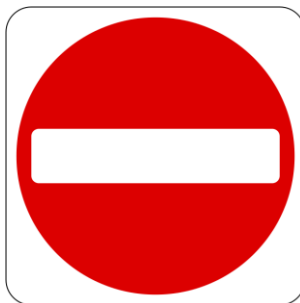




Shortlisted Traffic Sign for PMD



Priority Sign -
Pedestrian Crossing



Prohibitory Sign - No Entry & No Jaywalking



Informatory Sign -
Pedestrian Crossing



Mandatory Sign -
Pedestrian Crossing

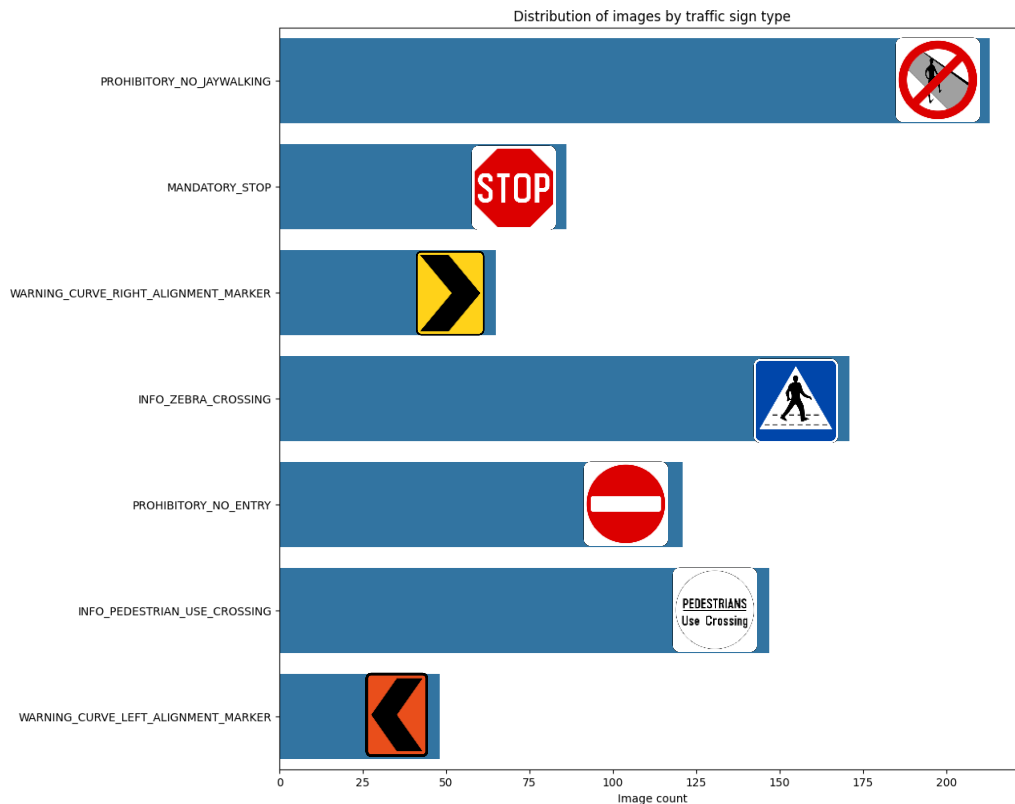


Temporary Left / Warning
Curve Marker





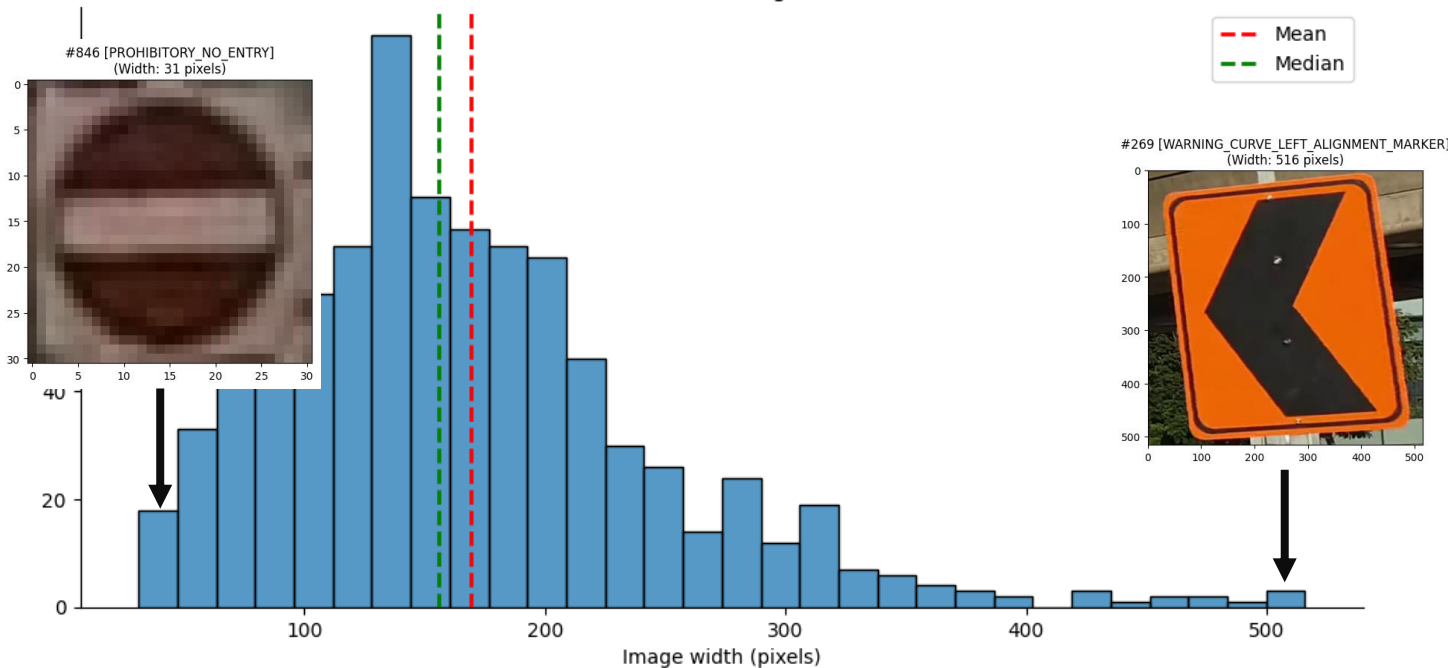
Proportion of Traffic Signs





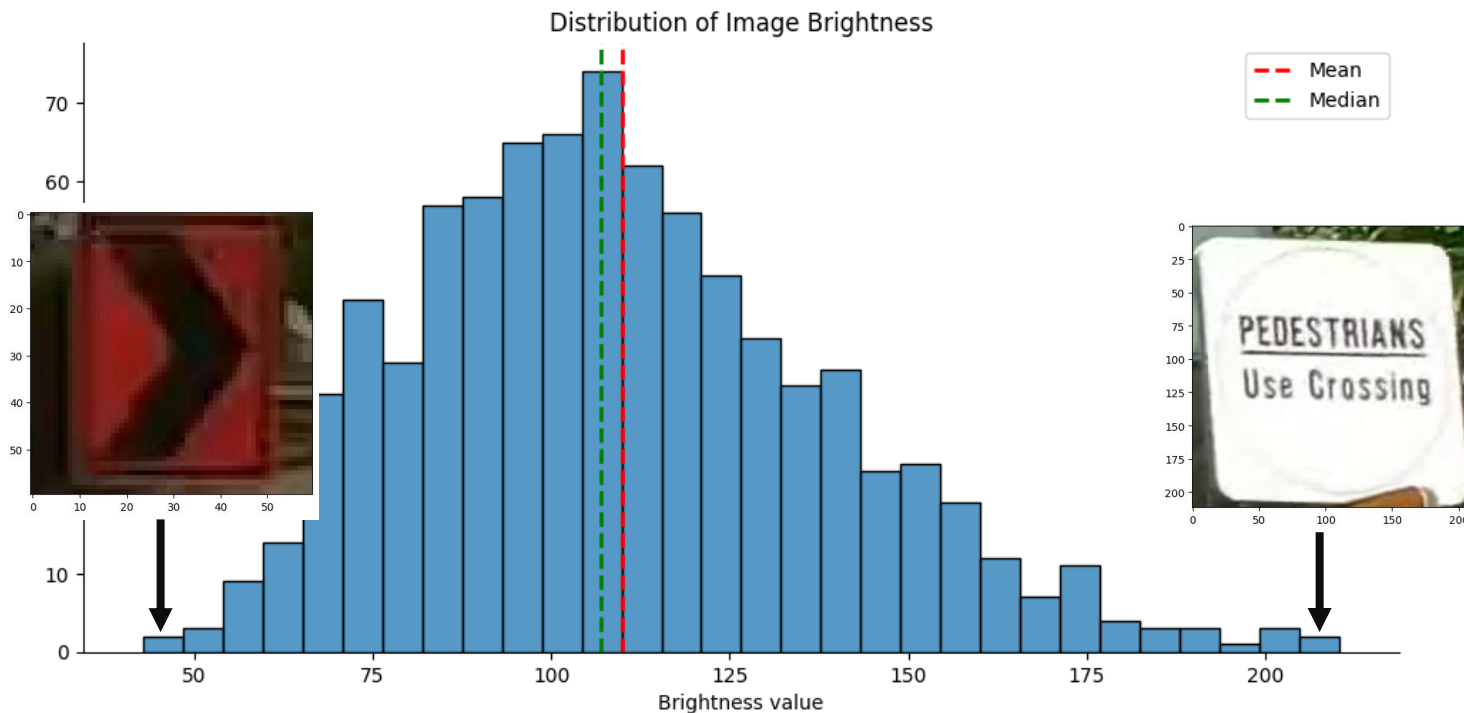
Resolution of Traffic Sign Images

Distribution of Image Widths





Brightness of Traffic Sign Images





Annotation of Unlabeled Traffic Image

- After data EDA, let's label our data!

Platform for annotation:  **roboflow**



Upload
Images



Classify
Object by
labelling



Image
Augmentation



Data Ready &
Exported as
YOLOv8



Annotation of Unlabeled Traffic Image

How to annotate?



1. Identify the objects in the image
2. Draw a bounding box for 1st object
3. Classify the object
4. Repeat for the rest of the objects

We will follow the center of the object, and draw a bounding box around it. We will also record the object's name, and its x, y, height and width information in the label file.





Image Augmentation

3 methods to boost the image counts!

Saturation

Saturation

Saturation
Randomly adjust the vibrancy of the colors in the images.

0% 60% 99%

original

-60% 60%

Warning: These settings are outside of the typical range and may produce poor results.

What is the saturation augmentation?
It randomly adjusts your images' colors to make them more or less vibrant.
[via Roboflow Blog](#)

Go Back Apply

Adjust the saturation $\pm 60\%$

Rotation

Rotation

Rotation
Add variability to rotations to help your model be more resilient to camera roll.

0° 5° 45°

0°

-5° 5°

Why should I use the Random Rotate augmentation?
It helps your model detect objects even when the camera or subject are not perfectly aligned.
[via Roboflow Blog](#)

Cancel Apply

Rotate the orientation $\pm 5\%$

Blur

Blur

Blur
Add random Gaussian blur to help your model be more resilient to camera focus.

0px 1px 25px

0px

1px

When should I use Random Blur?
If your subjects in-the-wild might not be in focus or your model is overfitting on hard edges.
[via Roboflow Blog](#)

Cancel Apply

Apply Gaussian blur with 1px



Image Preprocessing

2613 Total Images

[View All Images →](#)



Dataset Split

TRAIN SET

90%

2360 Images

VALID SET

6%

169 Images

TEST SET

3%

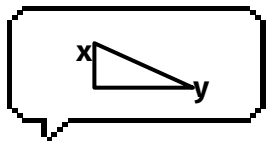
84 Images



Preprocessing

Resize: Stretch to 640x640



BEFORE Augmentation and Preprocessing

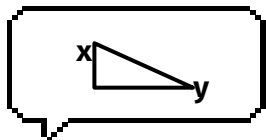




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Content	Car, pedestrian, truck and traffic lights	7 traffic signs related with PMD/Pedestrian
Sources	 roboflow	
Readiness	Ready for modelling	Raw images



AFTER Augmentation and Preprocessing

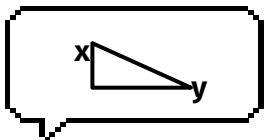
Level Up





	Udacity Self Driving Car	Singapore Traffic Sign
Images	15,000 images	2513 images
Annotation	97,942 labels	2513 labels
No. of Class	12	7
Resolution	512 x 512 Pixels	Not fixed 640 x 640 Pixels resolution
Content	Car, pedestrian, truck and traffic lights	7 traffic signs related with PMD/Pedestrian
Sources	 roboflow	 roboflow
Readiness	Ready for modelling	Ready for image Ready for modelling



Merging both image dataset



	Udacity Self Driving Car	Singapore Traffic Sign
Images	15,000 images	2613 images
Annotation	97,942 labels	2613 labels
No. of Class	12	7
Resolution	512 x 512 Pixels	640 x 640 Pixels
Content	Car, pedestrian, truck and traffic lights	7 traffic signs related with PMD/Pedestrian
Sources	 roboflow	 roboflow
Readiness	Ready for modelling	Ready for modelling



Before that... let's look at the classes

Udacity Self Driving Car

plaintext

```
biker                # Class 0
car                  # Class 1
pedestrian           # Class 2
trafficLight         # Class 3
trafficLight-Green   # Class 4
trafficLight-GreenLeft # Class 5
trafficLight-Red     # Class 6
trafficLight-RedLeft # Class 7
trafficLight-Yellow  # Class 8
trafficLight-YellowLeft # Class 9
truck                # Class 10
```

Singapore Traffic Sign

plaintext

```
curveleft_sign      # Class 0
curveright_sign     # Class 1
mandatorystop_sign  # Class 2
noentry_sign        # Class 3
nojaywalking_sign   # Class 4
pedestriancrossing_sign # Class 5
zebracrossing_sign  # Class 6
```



Merging both image dataset



Download
Dataset as
YOLOv8



Combine
images and
labels



Merge
classes



Update
data.yaml file

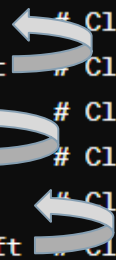


Before that... let's look at the classes

Udacity Self Driving Car

plaintext

```
biker                # Class 0
car                  # Class 1
pedestrian           # Class 2
trafficLight          # Class 3
trafficLight-Green    # Class 4
trafficLight-GreenLeft # Class 5
trafficLight-Red       # Class 6
trafficLight-RedLeft   # Class 7
trafficLight-Yellow    # Class 8
trafficLight-YellowLeft # Class 9
truck                 # Class 10
```



Singapore Traffic Sign

plaintext

```
curveleft_sign      # Class 0
curveright_sign      # Class 1
mandatorystop_sign  # Class 2
noentry_sign         # Class 3
nojaywalking_sign    # Class 4
pedestriancrossing_sign # Class 5
zebracrossing_sign   # Class 6
```

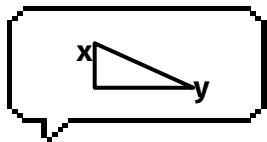
Combined Dataset

yaml

```
names:
- nojaywalking_sign      # Class 0
- mandatorystop_sign     # Class 1
- curveright_sign        # Class 2
- zebracrossing_sign     # Class 3
- noentry_sign           # Class 4
- pedestriancrossing_sign # Class 5
- curveleft_sign         # Class 6
- biker                  # Class 7
- car                    # Class 8
- pedestrian             # Class 9
- trafficlight            # Class 10
- trafficlight_green      # Class 11
- trafficlight_red        # Class 12
- trafficlight_yellow     # Class 13
- truck                   # Class 14
```



Merging both image dataset



	Udacity Self Driving Car	Singapore Traffic Sign	Combined Dataset
Images	15,000 images	2613 images	17,613 images
Annotation	97,942 labels	2613 labels	100,555 labels
No. of Class	12	7	15 [was 19 before merging traffic light]
Content	Car, pedestrian, truck and traffic lights	7 traffic signs related with PMD/Pedestrian	7 traffic signs, car, pedestrian, truck and traffic lights



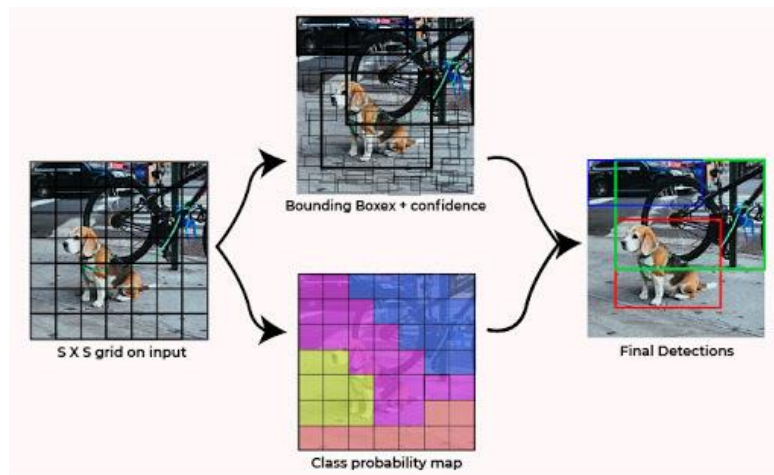
03

Data Modelling & Hyperparameter tuning





What is YOLO?



YOLO (You Only Look Once) is a fast, efficient real-time object detection system that uses convolutional neural networks (CNNs). It detects multiple objects in images or videos with a single look.



Models

PyTorch
Simple CNN

Simple CNN with Pytorch framework, a basic multi-class single-prediction model with Singapore Traffic Sign Data only

YOLOv8

Pytorch based CNN pre-trained model. Multi-class multi-prediction model with Singapore Traffic Sign Data only

Pytorch based CNN pre-trained model. Multi-class multi-prediction model with Singapore Traffic Sign + Udacity data



Specification of models

Feature	SimpleCNN Model	YOLOv8 Model (Singapore Traffic Sign)	YOLOv8 Model (Singapore Traffic Sign + Udacity data)
Framework	PyTorch	YOLO	YOLO
Model Type	Custom simple CNN	Pre-trained YOLOv8s model	Pre-trained YOLOv8s model
Input Size	50x50 pixels	640x640 pixels	640x640 pixels
Batch Size	128 for training and validation; 1 for testing	8	8
Epochs	50	20	25
Main Operations	Convolution, ReLU activation, pooling, fully connected layers	Convolutional operations optimized for object detection	Convolutional operations optimized for object detection
Optimization Algorithm	RMSprop with a learning rate of 0.001	Not specified, likely configurable in YOLO setup	Not specified, likely configurable in YOLO setup
Loss Function	CrossEntropyLoss	Typically a composite loss suitable for object detection tasks	Typically a composite loss suitable for object detection tasks
Output	Class scores for 7 classes	Bounding boxes with class probabilities and objectness scores	Bounding boxes with class probabilities and objectness scores
Use Case	Basic image classification	Advanced object detection in images	Advanced object detection in images

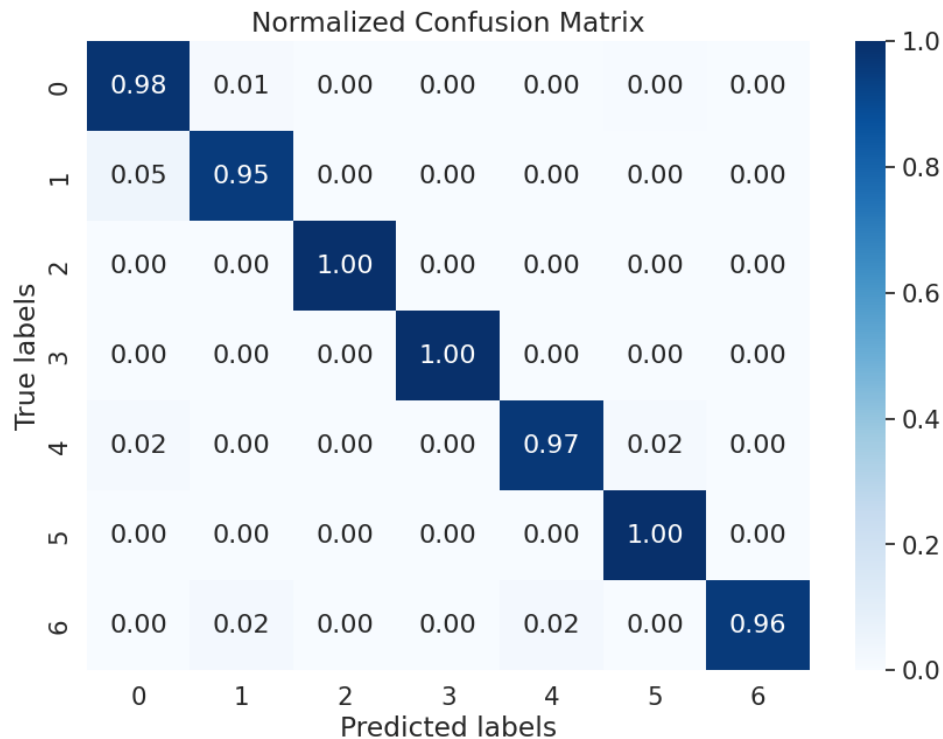


PyTorch Simple CNN Result

plaintext

```
curveleft_sign      # Class 0
curveright_sign     # Class 1
mandatorystop_sign  # Class 2
noentry_sign        # Class 3
nojaywalking_sign   # Class 4
pedestriancrossing_sign # Class 5
zebracrossing_sign  # Class 6
```

98.3%
Accuracy

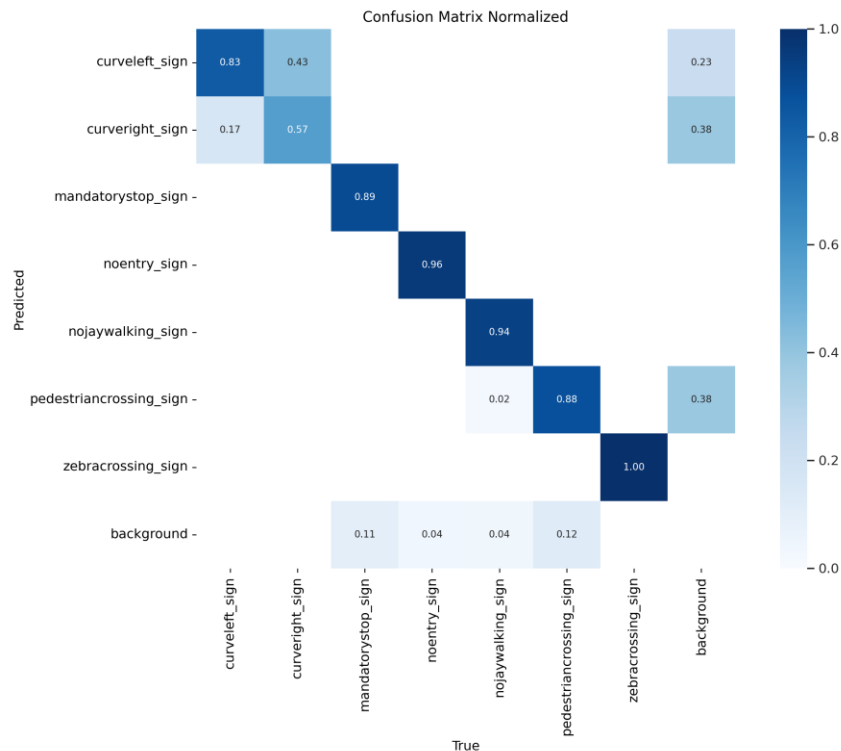




YOLOv8 with Traffic Sign Data



92%
Sensitivity





YOLOv8 with Master Data

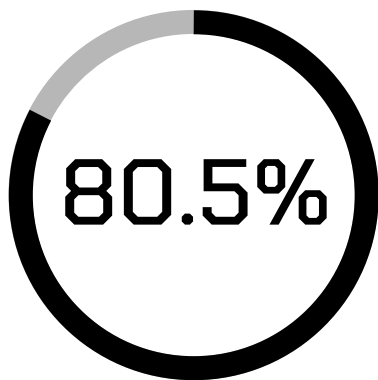




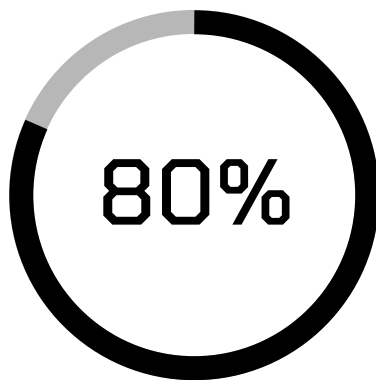
Yolov8 Hyperparameter Tuning

Learning Rate
Batch Size

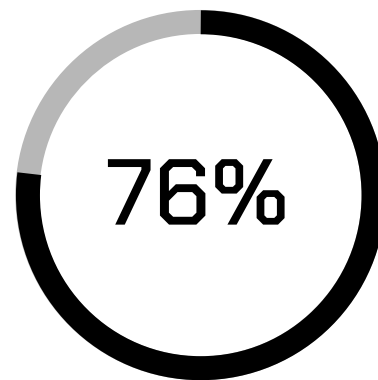
: 0.001, 0.01 and 0.1
: 8 and 16



Based Model



Batch size = 16



Batch size = 8

Results of different learning rate are the same.
Proceed with Based Model.



04

Demonstration





Traffic Sign + Self Drive Car Yolov8 Multiclass Multi Prediction



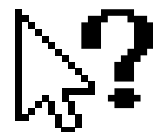


Video Demo



05

Conclusion and Recommendation





TheiaVision brings benefit to...

**Our Company
– MaximalSG**

1. Product Differentiation
2. Safety compliance

General Public

1. Increase safety and confidences
2. Better user experience

LTA

1. Safety Compliance
2. Collect data for Urban Planning

SCDF

1. Reduce frequency of deployment
2. Accurate Accident Reconstruction

**Insurance
Compines**

1. Reduction in Claims
2. Risk assessment and management



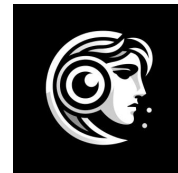
Conclusion

Problem Statement

How can we enhance the safety of Personal Mobility Devices (PMDs) in urban environments by using object detection to improve PMD users' ability to perceive and respond to their surroundings?

Conclusion

TheiaVision helps to detect object with 80.5% sensitivity





Recommendation

1. Handle imbalance datasets (SMOTE)
2. Include Diverse Image of Traffic Sign (Currently Data from DashCam Only, low resolution)
3. Stereo Video for depth estimation
4. Including hazard detection (pavement condition, construction, etc.)
5. Install Speaker for Voice Feedback to PMD Users

