

Mapping Main Roads Line Marking Inventory using Machine Learning

Project team

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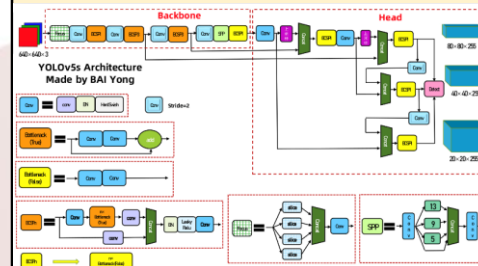
Project overview



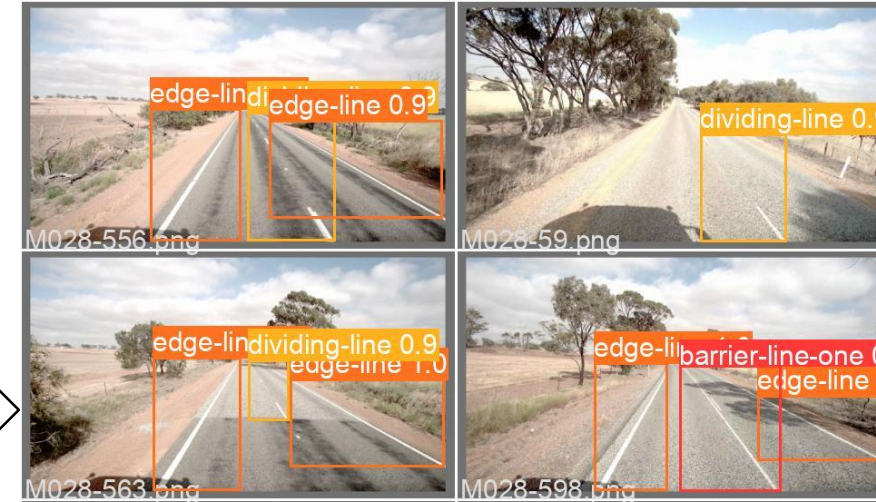
Deep learning-based method

for

- line marking detection and
- line type inference



Inventory



Road Name	Direction	Frame	SLK	Line Type	Barrier line one	Barrier line both	Edge line	Dividing line	Continuity line	Ground Truth	Accuracy
M026	L	1368	40	8	0	1	2	0	0	8	TRUE
M026	L	1369	40.02	8	0	1	2	0	0	8	TRUE
M026	L	1370	40.04	3	0	1	0	0	0	3	TRUE
M026	L	1371	40.06	3	0	1	0	0	0	3	TRUE

M026	L	1383	40.3	3	0	•••	1	0	0	0	3	TRUE
M026	L	1384	40.32	3	0	•••	1	0	0	0	3	TRUE
M026	L	1385	40.34	3	0	•••	1	0	0	0	3	TRUE
M026	L	1386	40.36	3	0	•••	1	0	0	0	3	FALSE
M026	L	1387	40.38	3	0	•••	1	0	0	0	3	TRUE

Road Name	Direction	Frame	SLK	Line marking type	coordinates_xmin	coordinates_ymin	coordinates_xmax	coordinates_ymax
H006	L	1	33.7	edge-line	0.73	0.6	1.0	0.84
H006	L	1	33.7	edge-line	0.29	0.45	0.5	1.0
H006	L	1	33.7	barrier-line-both	0.53	0.45	0.81	1.0
H006	L	2	33.73	edge-line	0.29	0.55	0.47	1.0
H006	L	2	33.73	edge-line	0.73	0.6	1.0	0.85
H006	L	2	33.73	barrier-line-both	0.56	0.52	0.81	1.0

Background

Pavement markings are important for traffic regulation and guidance.

MRWA would like to collect inventory data of pavement markings using computer-aided approaches.

MRWA archived pavement video for multiple road regions. In this project, data of the following regions are provided:

- RA01 Great Southern
- RA02 South West
- RA05 Goldfields – Esperance
- RA06 Kimberley
- RA07 Metropolian
- RA08 Wheatbelt (With ground truth)
- RA11 Pilbara
- RA14 Mid West-Gascoyne

Line marking and line type



- Different types of line markings are presented.
- Line type is a combination of line markings on a given location of road ^[1].

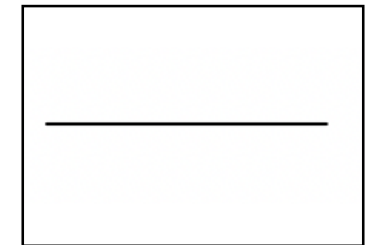
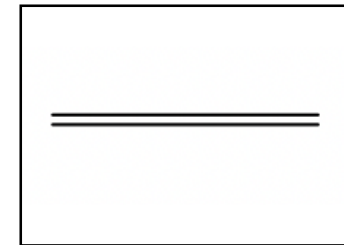
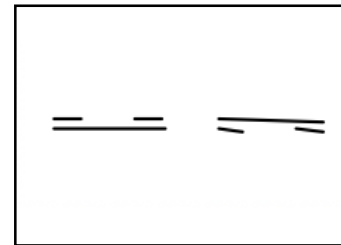
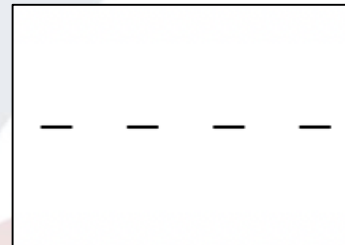
Dividing &
Continuity line

Barrier line –
One way

Barrier line –
Two way

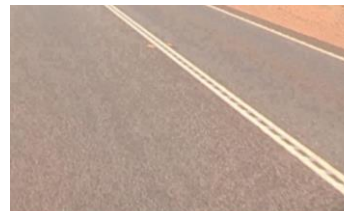
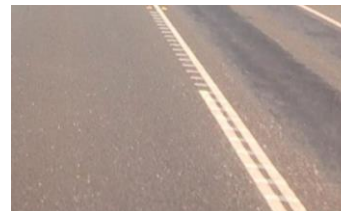
Edge line

Line type in
standards



- Example of the raw video data

Line type in
images
(real-life)



[1] WBR Longitudinal Line markings inventory database

Objectives

This project aims to

- Make full use of road pavement video data archived in Main Roads Western Australia (MRWA).
- Automatically keep updated the inventory data of pavement markings for various managerial operations.

Methods

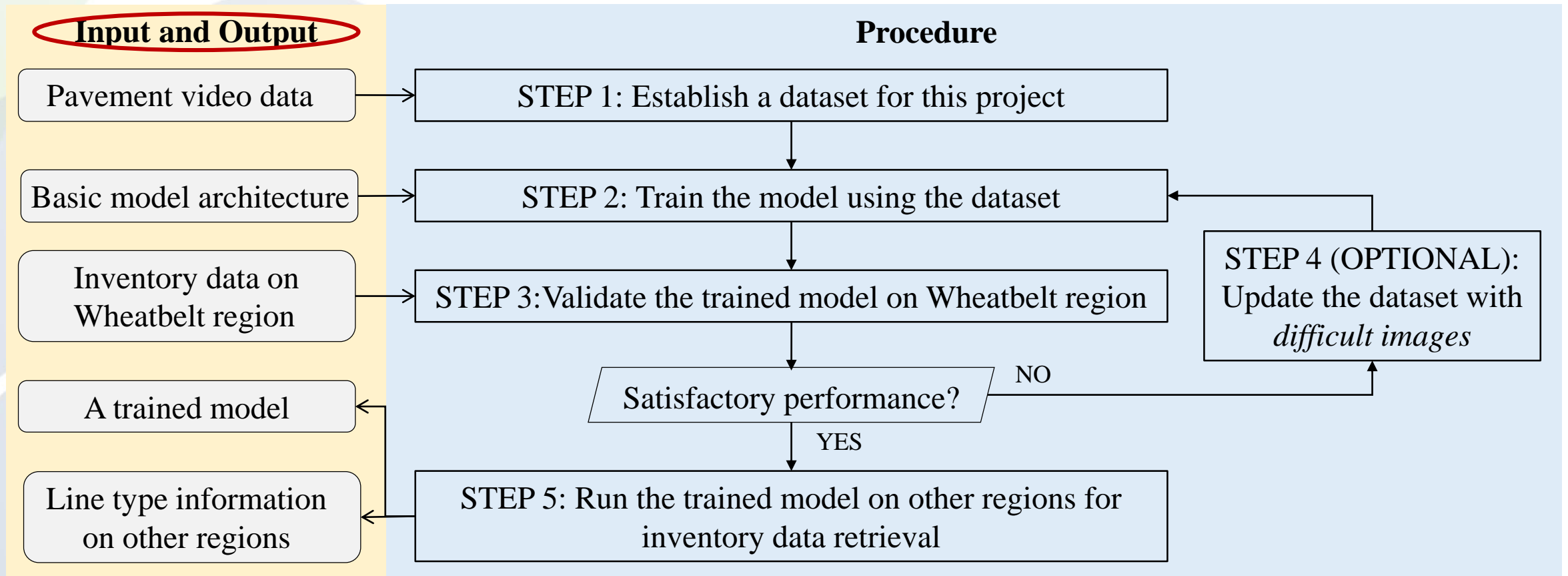
This project employs

- A deep learning algorithm to detect individual line markings;
- A rule-based approach to infer line types;
- A validation step to improve the performance of the developed tool.

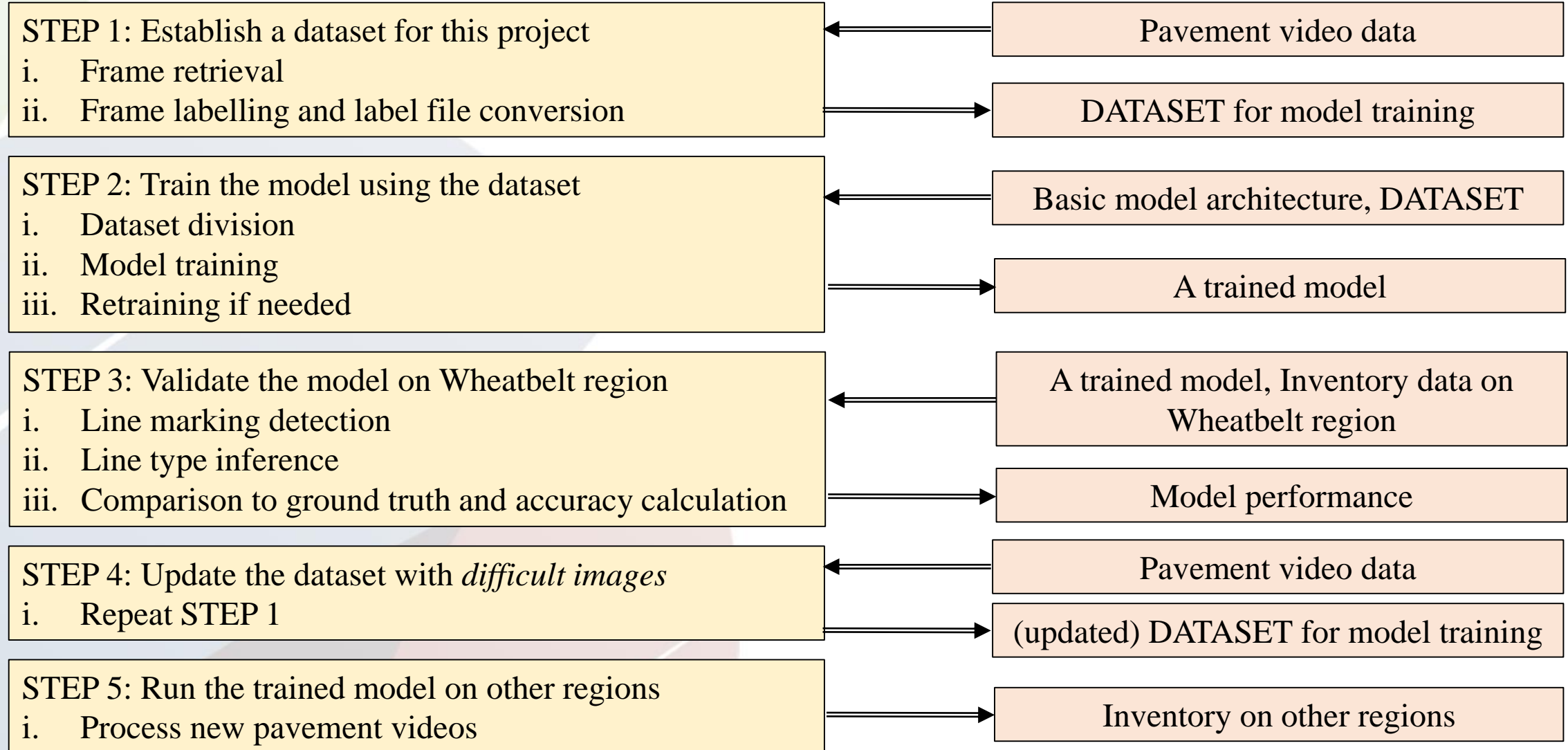
Advantages:

- MRWA conducts video survey of their roads regularly for multiple managerial operations, this project can make full use of such data for inventory purposes.
- The developed tool can automatically retrieve the line-type information with satisfactory accuracy.
- The developed tool supports further training.

Methods



Procedure

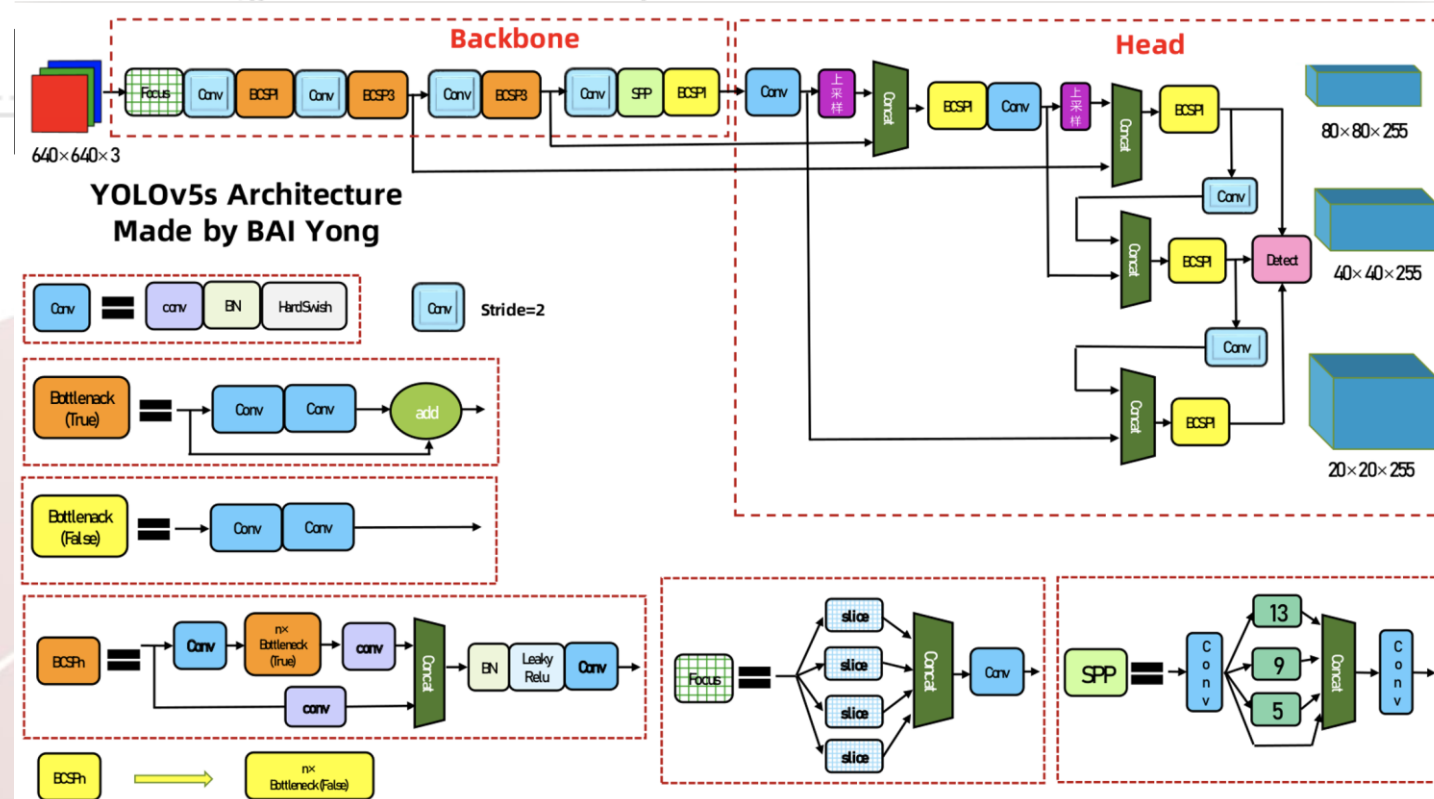


Yolo for object detection

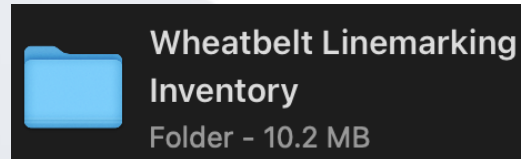
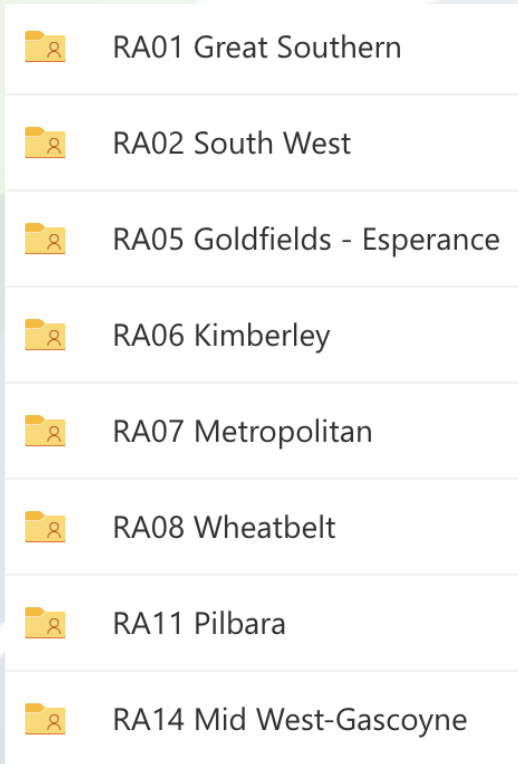
RCNN		Fast RCNN		Faster RCNN		YOLO	
region proposal module		region proposal module		RPN			
feature extraction network		detection network		Fast RCNN		YOLO network	
classifier	locator	classification	regression				

- Revolution of object detection algorithms

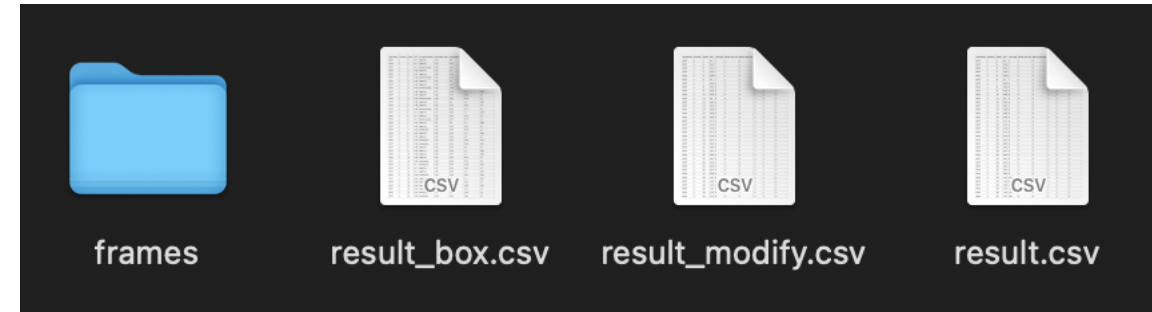
- You Only Look Once (yolo) architecture



Inputs and outputs



- The **inputs** mainly include
- Video data of multiple regions
 - Wheatbelt inventory
 - Basic object detection model (i.e., yolo)



- The **outputs** mainly include
- Frames with marked line markings (optional)
 - Line marking detection results (including coordinates)
 - Line type identification results (raw)
 - Line type identification results (modified)

The developed tool

DATASET PREPARATION

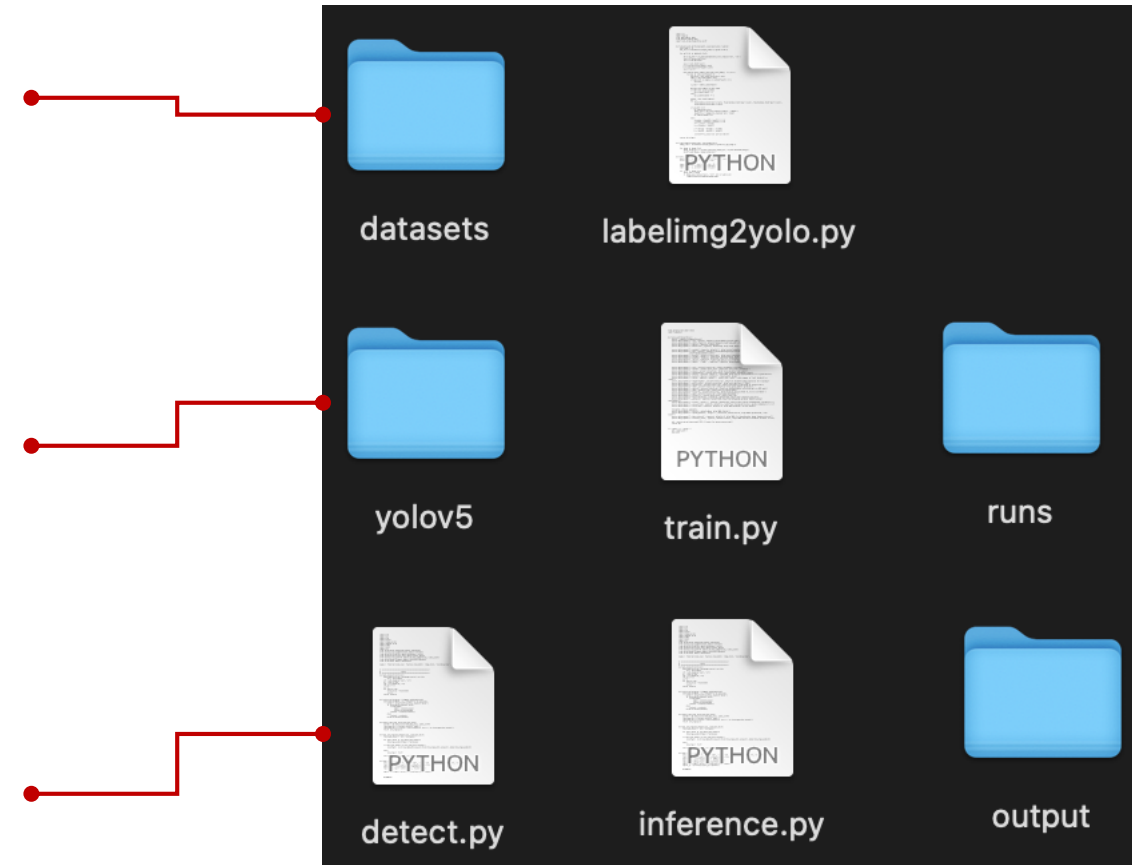
- i. Images and labels generated using labelling tool is put in datasets/road/labelimg
- ii. Use labeling2yolo.py to convert labels into yolo format
- iii. Other input data (e.g., line type def and ground truth) is put in the datasets folder

MODEL TRAINING

- i. Basic yolo model in a separate folder yolov5
- ii. Use train.py to train the yolo model with custom dataset
- iii. model parameters and weights are stored in runs/train/

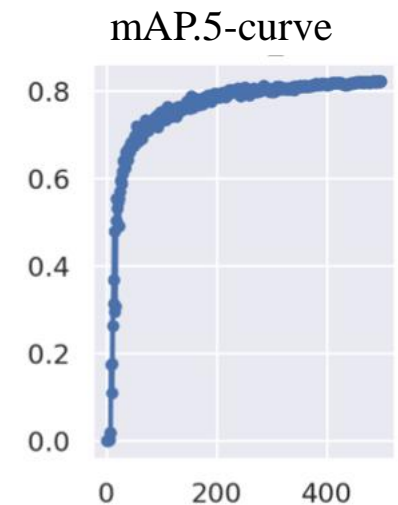
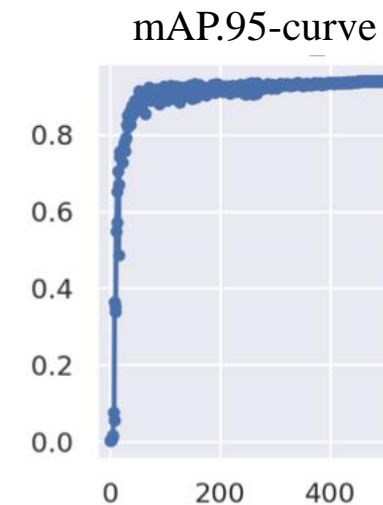
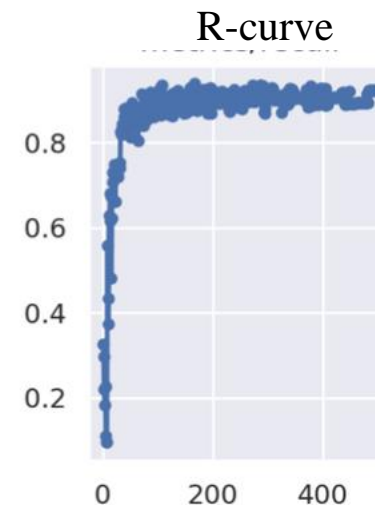
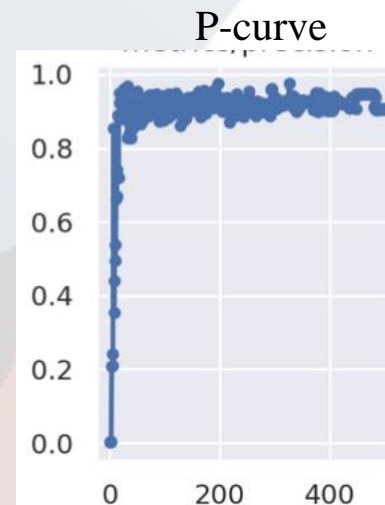
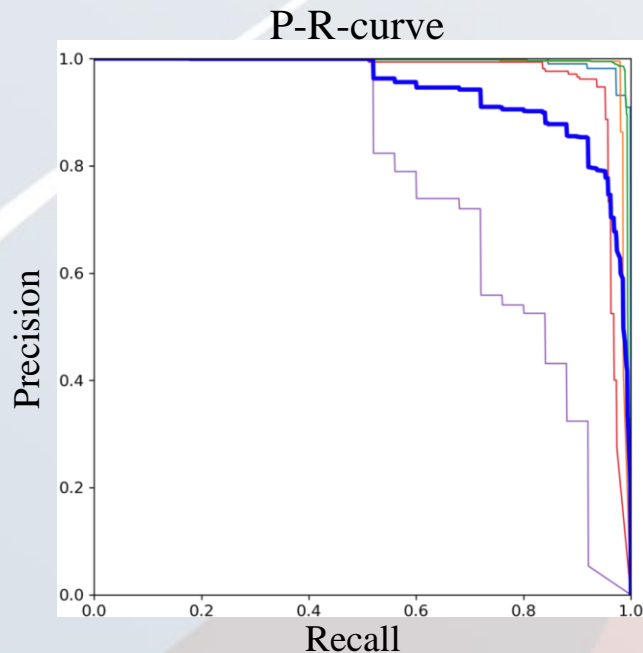
LINE TYPE DETECTION

- i. Use inference.py to process pavement videos (if there is ground truth for accuracy check)
- ii. Use detect.py to process pavement videos (if no ground truth is available)
- iii. Processing results are put in output/.





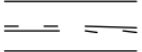
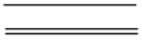
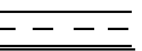


Model performance on the dataset

Line marking type	barrier-line -one	barrier-line -both	edge-line	dividing-line	continuity-line	All
P (Precision)	0.983	0.994	0.978	0.922	0.805	0.936
R (Recall)	0.995	0.988	0.981	0.929	0.825	0.944
mAP (mean average precision)	0.993	0.989	0.993	0.956	0.866	0.96



* The x axis represents the number of frames used for training.

Validation on the Wheatbelt region

Description	Base Code
 Edge Line Standard / Outline Marking (Right)	5R
 Dividing / Broken Separation & Edge Line Standard / Outline Marking	6
 Barrier Line Double One Way & Edge Line Standard / Outline Marking (2 Lane Road)	7
 Barrier Line Double Two Way & Edge Line Standard / Outline Marking (2 Lane Road)	8
 Overtaking or slow vehicle lane comprising of; Dividing / Broken Separation Barrier Line Double Two Way and Edge Line Standard / Outline Marking	9
 Overtaking or slow vehicle lane comprising of; Dividing / Broken Separation Barrier Line Double One Way and Edge Line Standard / Outline Marking	10
 Multi laned carriageway comprising of; Dividing / Broken Separation Barrier Line Double Two Way Dividing / Broken Separation Edge Line Standard / Outline Marking	11

- Line type definition based on line marking detection results

line type	barrier-line-one	barrier-line-both	edge-line	dividing-line	continuity-line
5R	0	0	1	0	0
6	0	0	2	1	0
7	1	0	2	0	0
8	0	1	2	0	0
9	0	1	2	1	0
10	1	0	2	1	0

- Ground truth examples

Road Number	SLK start	SLK end	Line Type
H005	56.34	56.355	16L
H005	56.34	56.61	5R
H005	56.34	56.61	19
H005	56.345	56.37	5R
H005	56.355	56.61	5L
H005	56.37	56.43	16R

...

H005	57.805	58.15	6
H005	58.15	58.45	7
H005	58.45	59.28	8
H005	59.28	59.535	7
H005	59.535	59.625	6
H005	59.625	59.69	7

Validation on the Wheatbelt region

Format 1 – Line type per frame

Road Name	Direction	Frame	SLK	Line Type	Barrier line one	Barrier line both	Edge line	Dividing line	Continuity line	Ground Truth	Accuracy
M026	L	1368	40	8	0	1	2	0	0	8	TRUE
M026	L	1369	40.02	8	0	1	2	0	0	8	TRUE
M026	L	1370	40.04	3	0	1	0	0	0	3	TRUE
M026	L	1371	40.06	3	0	1	0	0	0	3	TRUE
...											
M026	L	1383	40.3	3	0	1	0	0	0	3	TRUE
M026	L	1384	40.32	3	0	1	0	0	0	3	TRUE
M026	L	1385	40.34	3	0	1	0	0	0	3	TRUE
M026	L	1386	40.36	3	0	1	0	0	0		FALSE
M026	L	1387	40.38	3	0	1	0	0	0	3	TRUE
											0.87022

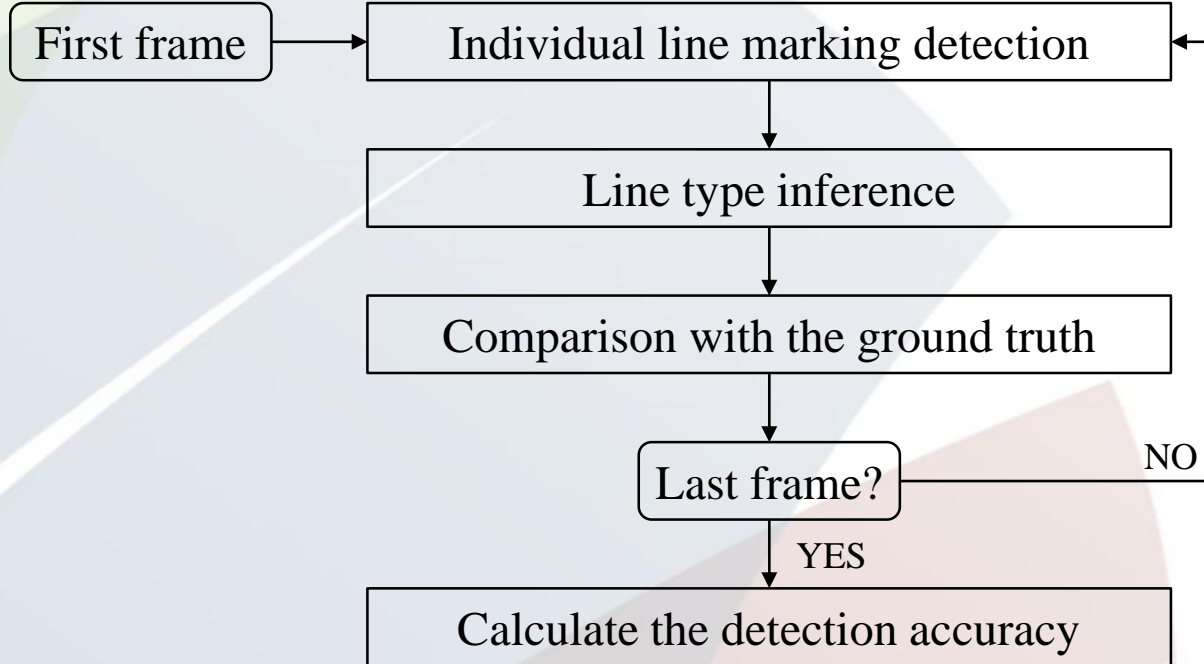
Format 2 – Individual line marking and coordinates

Road Name	Direction	Frame	SLK	Line marking type	coordinates_xmin	coordinates_ymin	coordinates_xmax	coordinates_ymax
H006	L	1	33.7	edge-line	0.73	0.6	1.0	0.84
H006	L	1	33.7	edge-line	0.29	0.45	0.5	1.0
H006	L	1	33.7	barrier-line-both	0.53	0.45	0.81	1.0
H006	L	2	33.73	edge-line	0.29	0.55	0.47	1.0
H006	L	2	33.73	edge-line	0.73	0.6	1.0	0.85
H006	L	2	33.73	barrier-line-both	0.56	0.52	0.81	1.0

- There are two formats of excel table provided as detection results for each video.
- For Format 1, there will be a raw detection result table and a modified one. An example of the latter is presented.

Validation on the Wheatbelt region

Procedure



Results

Road Name	Accuracy	Road Name	Accuracy
H005	0.79	M020	0.91
H006	0.91	M026	0.87
H053	0.94	M028	0.94
H923	0.84	M031	0.93
M001	0.98	M033	0.95
M016	0.96	M038	0.77
M017	0.93	M040*	N/A

* The ground truth for M040 is not included in the inventory provided.

Validation on the Wheatbelt region

Note:

The following cases are excluded during the accuracy check:

- Frames with multiple rows of line types according to the ground truth.
- Frames with large markings OR island in the middle of the pavement (which are not assigned with a line marking code). Example frames are shown above.



Example frame: large marking in the middle of the pavement



Example frame: islands in the middle of the pavement

Validation on the Wheatbelt region

We did a re-training of the model given the unsatisfactory performance on the validation. Reasons causing errors include:

- Changing environmental factors (e.g., illumination and occlusion)
- Insufficient precision for labelling

Solution:

- Add frames where false detections occur
- Modify the labelling bounding box to be precise and consistent

Other limitations:

- Video corruption (e.g., H053)
- Inaccurate mapping between Frame No. and the SLK.
- Unsuccessful detection for large markings, islands and kerbs.

Project deliverables

The **deliverables** of this project will include the following:

- The source code of the developed tool for line type detection and its guideline.
- Detection results (in two formats of excel sheets) for seven regions of road pavement.
- A formal report on this project.
- Presentation slides for monthly updates and this final meeting.

Please contact Nicholas Archer if you would require a copy of the deliverables.

Acknowledgements



This research has been developed with support provided by Australia's Sustainable Built Environment National Research Centre (SBEnrc). SBEnrc develops projects informed by industry partner needs, secures national funding, project manages the collaborative research and oversees research into practice initiatives. Core Members of SBEnrc include ATCO Australia, BGC Australia, Government of Western Australia, Queensland Government, Curtin University, Griffith University, RMIT University and Western Sydney University. This research would not have been possible without the valuable support of our core industry, government and research partners.





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